MADRAS FISHERIES BUREAU.

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MADRAS FISHERY INVESTIGATIONS, 1908.

BY

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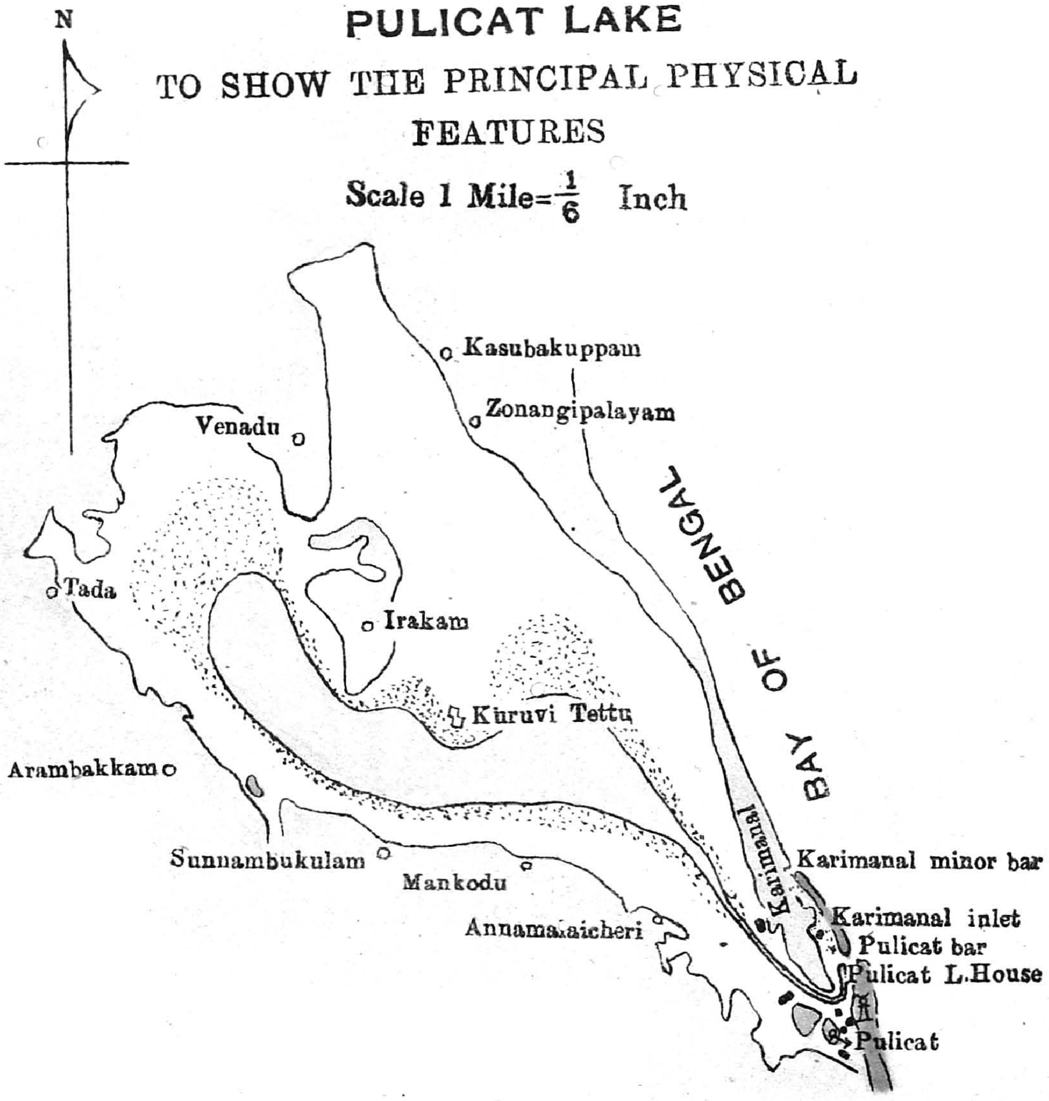
Sketch Plan

of

PULICAT LAKE

TO SHOW THE PRINCIPAL PHYSICAL FEATURES

Scale 1 Mile=$\frac{1}{6}$ Inch



REFERENCE

Indicates depths of 3½ feet & upwards	Datum M. S. L.
Do. do. between 2½ & 3½ feet	
Do. the area which dries in exceptionally dry years with accompanying closure of the bar	
Oyster beds around Pulicat	

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1909

REPORT

ON

THE SUITABILITY OF PULICAT LAKE FOR OYSTER-CULTURE,

BY

JAMES HORNELL, F.L.S.

[*One Sketch Plan.*]

I.—Location and Characteristics of the several Beds and Patches now existing.

During three weeks in August 1908 devoted to a tour of inspection of Pulicat Lake, I was able to locate eight distinct beds and patches of edible oysters. I believe the search, which extended from Yedamani kuppam in the south to Tada, Venadu and Kasuba kuppam in the north, was exhaustive and that these eight locations comprise every bed at present existing.

Taking them in order from south to north and assigning them distinctive names appropriate to their situations, they are—

(1) Yedamani kuppam bed.
(2) Pulicat bed.
(3) Lighthouse bed.
(4) Kotta kuppam bed.
(5) Sinna paraval bed.
(6) Pudupettai bed.
(7) Karimanal inlet bed.
(8) Vannanturai bed.

Of these, the Sinna paraval, Karimanal inlet, Vannanturai and Lighthouse beds are of greatest importance; they may therefore receive first attention.

Sinna Paraval Bed.

This, the most extensive of presently existing oyster settlements, is situated as a deposit of scattered patches along the north-west shore of the northernmost of the Pulicat Islands. To reach it we pass through the channel separating Pulicat Island from Karimanal and then turn west into the shallow arm of the lake called Sinna paraval which lies between Pulicat and the mainland on the west and north-west.

The eastern end of the bed is about half a mile from the northern end of the canal cutting facing Karimanal, and extends as a rather narrow band, following the curve of the land, for some three-quarters of a mile to the south-west.

When first visited at about half-tide, the majority of the oysters lay in water not more than one foot and a quarter in depth. The higher bunches were actually awash, and on a later visit, which coincided with the time of low-tide, a considerable number were wholly uncovered.

The oysters in this bed are characteristically elongate, long and narrow or sub-spatulate in form and of remarkably regular growth habit. They tend to segregate into clusters varying from three and four individuals in each to massive clumps of treble these numbers. Towards the higher parts of the patches and especially towards the centres, the clumps are closely crowded, gradually thinning out till, along the margins, the clusters are found to consist of a very limited number of individuals and to be sparsely scattered over the bottom. It is noteworthy that the density of population is in inverse ratio to the depth of water—the oysters crowd the shallower parts and become scarce and ultimately disappear as the water deepens. A tendency to grow upwards, to raise the ventral margin by growth towards the surface of the water, is most strongly developed and accounts for the marked dorso-ventral elongation of the shell. Another notable feature characterising growth is the habit of these oysters to retain their own individuality in the clusters; for each to keep the greater portion of its shell free from cohesion with those of its neighbours, due to a slight amount of radial divergence in the direction of growth among the oysters of each group.

The latter habit produces very serviceable clusters, readily separable into units, as the area of mutual cohesion is small and limited to the massive dorsal region of the convex valve. The joint made by the adherent surfaces is also imperfect, rendered weak by the muddy scum present on one valve when the other was in course of becoming attached to it.

The only cultch existing on this bed consists of the dead shells of former oyster generations. The bottom is very muddy both on the bed and for a long distance in every direction around. Deeper water, up to $1\frac{1}{2}$ and $2\frac{1}{4}$ feet, is found along each side of the bed and the probability is that the elongate shoal which forms the basis of the bed has arisen by accretion of the shells of successive generations of oysters; a gradual accumulation of hard material has occurred and provides from generation to generation the only foot-holds or landing places in a sea of surrounding mud, for successive broods of oysters.

The valves of these oysters are slimy to the touch, and have the appearance of being encrusted with a thin muddy felting.

Under the microscope this coating is seen to consist of a basal layer of short green conferva rooted to the surface of the shell, while the tangled filaments are smothered and hidden by a dense gathering of myriads of diatoms of many genera and species, many sponge spicules, minute grains of sand, and a large bulk of mud particles; a delicate red brown filamentous alga is also frequently present as a principal constituent of the feltlike covering.

The higher clusters of oysters, those exposed each tide, are otherwise almost bare of adhering organisms; those in deeper water which are never uncovered are usually veiled by a luxuriant growth of algæ several inches in height.

Barnacles (*Balanus*) may be said to be wholly absent—a characteristic feature of this bed. A small dark coloured species of mussel, of which the largest was under $\frac{1}{4}$ inch long, was abundant in the crevices around the bases (dorsal attachment) of the oyster clusters, together with a white Saxicava-like lamellibranch.

Little reliable information could be gleaned anent the past history of the bed; the people of this district do not use oysters as food, and the demand from outside is too trivial to count. Hence I could learn nothing as to the spawning season, but I was informed by a man who occasionally collects oysters to supply orders from Madras, that this bed dries up completely during specially dry seasons and that the whole of the oysters then die off. Subsequently I learned that May to June 1905 was an unusually dry season, and as the bar was closed during these months the level of water in the lake receded to an extent that has not since recurred; that the whole of the lake bottom between the islands of Venadu and Irakam on the one side and the east shore line on the other, became dry and that the only parts left with water were the canal channels and the deeper stretches west and south of Venadu and Irakam.

I am satisfied from this evidence and from some other considerations that at least the main mass of oysters forming this bed in the early part of 1905 perished during the dry season of that year, and that the present generation dates from a spatfall subsequent to that catastrophe. The dimensions of the now existing generation are roughly those we find in European oysters of four to five years of age, but I consider we are fully justified in assuming them to be not more than three years old at the present date (September 1908). An ample food supply and freedom from the restraint upon growth imposed by the low temperature of European winters will account for their size being so superior to that of three-years-old European oysters.

In this connection it may be noted that the temperature of water over this bed on 23rd August 1908 was 85° F., while the specific gravity was 1,027·50. The temperature of the air in the shade was 84° F. Time of day 5 P.M.

The dimensions of six individuals taken at random were as follows :—

Depth (Dorso-ventral).	Length.	Thickness.
INCHES.	INCHES.	INCHES.
$5\frac{1}{4}$	$2\frac{3}{4}$	$1\frac{1}{2}$
$4\frac{1}{4}$	$2\frac{1}{4}$	1
5	$2\frac{1}{2}$	1
$5\frac{3}{4}$	$2\frac{1}{2}$	1
$4\frac{1}{2}$	$2\frac{1}{2}$	1
$4\frac{1}{4}$	2	$\frac{3}{4}$

The average size of these may therefore be stated as $4\frac{5}{6}$ inches by $2\frac{5}{12}$ inches by $1\frac{1}{24}$ inch.

Dissection of a number of individuals showed the body or soft parts to be of rather small bulk as compared with the thickness and weight of the shell. The genital glands or gonads shared in this weakness of tissue development, but how far this may be due to seasonal causes we cannot say at present. Ripe ova and spermatozoa, in separate individuals, were present in the majority of cases but in small quantity; the appearance generally suggested that some considerable time must elapse before full development would be complete.

Examination under the microscope was made of the stomach contents, and these were found to agree in constitution with that of the algal felting coating the valves; of recognizable organisms, diatoms of several genera and species were by far the most abundant with occasional algal spores, and a considerable number of fragments of filamentous algæ, chiefly green. Sponge spicules, mostly slender rods with a slight knob at one end, were also frequently seen. The remainder of the material consisted of mud particles, vegetable debris, and a large quantity of minute sand grains.

Vannanturai Bed.

This bed lies at the head of a long and wide horn-shaped creek which passes westwards from the northern end of Karimanal inlet past the village of Vannanturai. The present bar entrance into Karimanal inlet is distant less than half a mile from the creek mouth in a south-east direction; the head of the creek in the present water conditions of the lake ends close to the village of Karimanal as marked on the district map. During

the rains or with an exceptionally high tide, the creek becomes continuous with the Sambasipalli kuppam creek to the southward, giving a free run of water through the former.

This Vannanturai oyster bed is much less extensive than that in the Sinna Paraval; in habit of growth, depth of water over the bed, origin and constitution of the cultch forming the foundation and surface of the bank or shoal on which the present oysters are found, there are no differences to be noted. As in the case of the first deposit described, the oysters on the higher part of the bank are uncovered at low tide; at this place the oysters are found most crowded, becoming sparser as the water deepens towards the middle of the creek.

The upright habit of growth prevails again here in a most marked degree and the muddy algal coating upon the valves, the flat one more especially, is greatly developed.

A considerable difference in average individual size from that of the Sinna Paraval oysters was apparent to the eye, and was emphasized when exact measurements were taken. A large proportion were $6\frac{1}{2}$ inches and over in dorso-ventral length; a correspondingly large size in other dimensions was also found as will be seen in the following table of the measurements of twenty oysters taken indiscriminately from a heap :—

Dimensions of 20 oysters from Vannanturai creek.

Number.	Depth (Dorso-ventral).	Length.	Thickness.
	INCHES.	INCHES.	INCHES
1	$8\frac{1}{2}$	$3\frac{1}{4}$	$1\frac{3}{4}$
2	7	$3\frac{1}{4}$	$1\frac{1}{4}$
3	4	$1\frac{3}{4}$	$1\frac{1}{4}$
4	4	$2\frac{3}{4}$	$1\frac{1}{4}$
5	$6\frac{1}{4}$	3	$1\frac{3}{4}$
6	7	$3\frac{1}{8}$	$1\frac{1}{2}$
7	$6\frac{3}{4}$	$3\frac{5}{8}$	$1\frac{1}{4}$
8	$5\frac{1}{4}$	$3\frac{1}{4}$	$1\frac{1}{4}$
9	$5\frac{1}{4}$	$2\frac{3}{4}$	$1\frac{1}{8}$
10	$7\frac{1}{4}$	3	$1\frac{3}{4}$
11	$7\frac{3}{4}$	$2\frac{3}{4}$	$1\frac{3}{8}$
12	$6\frac{1}{2}$	3	$1\frac{1}{16}$
13	$6\frac{1}{2}$	3	$1\frac{1}{2}$
14	$6\frac{1}{2}$	$3\frac{1}{2}$	$1\frac{1}{2}$
15	7	$3\frac{1}{4}$	$1\frac{1}{4}$
16	$6\frac{1}{4}$	3	$1\frac{1}{4}$
17	$6\frac{1}{2}$	$2\frac{3}{8}$	$1\frac{1}{8}$
18	$6\frac{1}{2}$	3	$1\frac{1}{4}$
19	$4\frac{1}{2}$	2	$\frac{3}{4}$
20	4	$2\frac{3}{4}$	$1\frac{1}{4}$

Average size . . 6·16 inches by 2·90 inches by 1·32 inch. This average compares very well with that of the Sinna Paraval oysters of 4·83 inches by 2·42 inches by 1·04 inch.

Associated molluscs were the same as in the Sinna Paraval bed; barnacles were markedly extremely scarce.

Stomach contents.—Diatoms appeared even more numerous than in the sample already described, the number of species being notably greater; algal spores and broken filaments were about the same in ratio, as also were sponge spicules. Minute thread worms, noted also in the algal matting on the valves, were particularly frequent, several being in the field of the microscope at one time. One minute *Daphnia*-like crustacean was noted. Sand grains and unrecognisable debris as before.

The bodies generally were far from plump, although somewhat larger, in consonance with the larger dimensions of the shells, than those from the Sinna Paraval. The gonads also were better filled, but still by no means fully developed, the appearance being that at least a couple of months were yet requisite to render them ripe for emission.

To assess the probable age of these oysters is difficult. We have already noted that owing to the great recession of the water level during the dry season of 1905, the Sinna Paraval oysters cannot be more than three years old, and yet the present ones appear so very much larger as to suggest greater age. If they are really older than the Sinna Paraval ones, then the only conclusion to come to is that the water in this creek was not reduced equally with that of the more inland branches of the backwater. This is hardly possible, for even if we grant that a great amount of water from the sea may enter Karimanal inlet and this creek by percolation through the closed bar during a dry season, the benefit of this supply will be distributed throughout the whole extent of the lake unless a bund be erected to separate the inlet and creek from the remainder of the lake. The probabilities therefore are that the majority of oysters on this bed did die off in 1905, that the present oysters are of the same age as those in the rest of the lake, and that their superiority in size is due to more rapid growth induced by more varied and more abundant food-supply consequent on their proximity to the rapid tide-flow entering at the Karimanal bar. In Karimanal inlet, the sea water is rich in minute organisms; in the Sinna Paraval the flow of water is sluggish and the plankton is often scanty. In the latter case the oysters feed largely upon organisms bred on their own valves and on the lake bottom adjacent; in the other the oysters besides having a similar supply have it supplemented by the varied food brought by the passing tide.

It is a significant fact that the oysters of the Vannanturai bed are all of the same generation. No younger generations

haye settled upon the valves of the older oysters, the variations in size which do exist being referable to unequal nutrition, as is so often seen in the case of a mussel scalp, so here those individuals most crowded are of distinctly smaller size than where they are more freely spaced.

The equal age of the whole of the oysters over the bed and the absence of younger generations were also noted when examining the Sinna Paraval bed.

Karimanal Inlet Bed.

This bed, which lies on the west side of Karimanal inlet, is situated about one-third up the inlet from its mouth and in a south-east direction from Sambasipallikuppam. The oysters here occur in deeper water than in either of the two beds already described, having a fairly even depth of from 1 to 1½ foot over them at low tide; none are exposed at low tide.

The bottom, on which they lie scattered irregularly in small bunches, is a black muddy sand. The bed covers a fairly extensive area; it is nowhere closely packed, and nowhere do we find a central shoal formed of a massed accumulation of the dead shells of former generations. We may conclude that in its origin it is considerably more recent than either the Sinna Paraval or the Vannanturai bed.

In appearance the oysters here differ greatly from those of the latter deposits. Instead of being markedly elongate, they are squat and shapely in form, the difference of ratio between length and breadth much less accentuated. The range in size and in presumptive age is also very considerable, and there can be no doubt that on this bed we meet with one principal and older generation and at least two younger generations rather poor in individual numbers. The various generations are mingled without regularity, the younger attached in the great majority of cases to the shells of the older. The range in age appears to run from one to three years.

The dimensions of six oysters of the oldest generation were found to be as follows:—

Length.	Depth.	Thickness.
INCHES.	INCHES.	INCHES.
$4\frac{1}{4}$	$6\frac{3}{4}$	$1\frac{1}{8}$
$3\frac{1}{8}$	$4\frac{1}{4}$	$1\frac{1}{2}$
$3\frac{1}{8}$	4	$1\frac{1}{4}$
$2\frac{3}{4}$	$3\frac{3}{4}$	$1\frac{1}{4}$
$2\frac{5}{8}$	$3\frac{3}{4}$	$1\frac{1}{2}$
$3\frac{1}{8}$	$4\frac{3}{4}$	$1\frac{1}{8}$

An average of 3·21 inches × 4·54 inches × 1·29 inch.

Considerable wealth of algal and animal life is present, in great part associated closely with the oysters by settlement upon the valves. Most conspicuous are barnacles and algæ, the latter frequently veiling the shells from sight. *The association of barnacles is characteristic.* The smaller crustacea, amphipods and small decapods, are numerous, while large terebellids and other tube-worms and several small lamellibranchs and gastropods, a small *Calyptraea* among the latter, shelter in the crevices of the bunches. Most interesting of all was the presence of two small pearl-oysters, *Margaritifera vulgaris*, two to three months old. A felt-like sponge, vivid green on the surface, yellow beneath, with *Clione* and a small *Sycon*, were the only sponges seen. Finally we have to note the lack of that diatomaceous muddy coating associated so characteristically with the Vannanturai and Sinna Paraval oysters. Here the shells are comparatively clean and bright where barnacles and tufted algæ do not adhere.

Of enemies or animals likely to prove harmful on an oyster bank, I noted two of some importance, one being the sponge *Clione* whose burrowing within the substance of the shell renders it rotten or "worm-eaten," the other a hirsute gastropod (*Murex sp.*), which may probably be the cause of some damage if its habits be the same as its congeners in Europe. *Clione* burrows were more marked here than on any other bed; the proximity of this bed to the sea favours the growth and increase of this enemy. *No starfishes were present.*

A considerable number of dead oyster shells were seen but dissection of a number of those found alive showed them to be remarkably healthy and far fatter and plumper in body and with genital glands better filled than those of oysters from any other bed in the lake. The majority of those examined were females, the gonads fairly full.

For table purposes these oysters are the finest of any now living in the lake.

Inshore of this scattered oyster bed, the cockle-like *Arca rhombea* is more abundant than anywhere else in this locality. This mollusc is remarkable for the dark red colour of its blood; it is here esteemed more highly than any other "cockle" (*matti*), being considered very nutritious.

Pulicat and Lighthouse beds.

These beds are said to have originated artificially; a few years ago oysters were occasionally in demand and to obviate the trouble of going frequently to the natural beds at some distance it became a custom to keep reserves of oysters in these two places—a primitive system of laying.

Both beds are patches of small extent, the Lighthouse bed considerably the larger. The oysters in both places are fairly well grown and may be classed as intermediate in character between those of Karimanal inlet and those of the Sinna Paraval. Some barnacles are present on the shells and a considerable amount of algæ. The Lighthouse bed lies in water from 6 inches to $1\frac{1}{2}$ feet in depth at low-tide (7th August), the bottom being black sandy mud without any cultch save dead oyster and mactra shells.

The sponge *Clione*, and the polychaet worm *Polydora*, both shell borers, were noted. Some mussels less than $\frac{1}{4}$ inch long were plentiful around the umbonal attachments of the oysters; other conspicuous life was very meagre.

The condition of the oysters was healthy but the bodies were small as compared with the weight of the shells. The gonads were not well filled. Average length (dorso-ventral depth) was $4\frac{1}{2}$ inches.

Yedamani Kuppam Bed.

This appears to be a natural oyster patch; it occupies a position where the conditions are naturally favourable to oyster spatting, being at the mouth of the creek which separates Yedamani Island from Pulicat town. The depth of water over the bed is from $1\frac{1}{2}$ to 2 feet at low water. The bottom is muddy sand; the cultch, dead oyster shells as usual. The channel of the canal runs alongside this bed and as the lake shallows on the other side of this patch, there is no room for any extension of this bed by culture. Presumptive age about 3 years.

Kotta Kuppam Bed.

Kotta kuppam bed lies on the south side of the channel between Pulicat and Karimanal and along the north edge of the long shoal which skirts Pulicat Island on the east. It is of no importance being small and incapable of extension. The oysters here are very scattered; many large dead shells are present. Habit and condition of the oysters are similar to those of the Lighthouse bed. Barnacles occasionally present; the bottom fairly clean sand. Age apparently 3 years.

Pudupettai Bed.

The last bed to be noted is the Pudupettai bed. It lies in a little bight of land immediately to the north of the Karimanal Canal lock in $\frac{3}{4}$ to 1 foot of water at low-tide. The oysters are thickly spread over a limited area; judging from the size the age would appear to be about 3 years. In the shallow tidal

lagoon a little north of this bed, oysters of similar size and appearance also occur in small clusters scattered sparsely, while everywhere in the vast stretch of very shallow water, ½ to 1 foot deep, which extends eastwards for over a mile from the western shore of the lake between Annamalaicheri and Kanavanturai, single oysters are found here and there, attached in most instances to dead *matti* shells, the only foothold avaliable. It is very evident that the presence or absence of oysters over the south end of Pulicat lake is almost entirely a matter dependent upon the presence or absence of cultch; every suitable scrap bears its colony of these molluscs and it is due to the great scarcity of cultch that the beds in Pulicat lake are so local and so restricted in extent. In this connection we may note that wherever the Canal Engineers have used laterite masonry, as in the revetment at locks and at entrances of canal cuttings into the lake, the blocks under water bear living oysters in considerable numbers.

II.—Physical Characteristics of Pulicat Lake.

Before we can be in a position to assess the potentialities offered by the great expanse of Pulicat lake for any form of aquiculture, ostreculture more particularly, we have first to marshal the principal facts in regard to the hydrography of the area. With this aim in view I ran a network of lines of soundings over the lake during my recent visit, took representative samples of the bottom where necessary, tested the salinity of the water at different distances from the bar, recorded temperatures, and gathered what information was possible anent the effects produced respectively by floods and by the occasional closure of the sea bar.

General features and past history.—Pulicat lake is by far the largest backwater on the eastern coast of the Madras Presidency. Its drainage area has been given by Russell * (1897) as 1,692 square miles and its high flood waterspread as 178 square miles. Its outline may be compared with that of an inverted squat bottle with short neck. The body of the bottle will then represent the inland sea which forms the northern section, Silka lake as it is known locally; the neck, the wide channel between Karimanal and Annamalaicheri, and the stopper by the contracted channel off Pulicat town. The length of the northern section is approximately 18 miles (from miles 30 to 48 on the canal), its width 10 miles.

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* History of the Buckingham Canal Project, Madras, Government Press, 1898.

The bar is situated near the south end, usually about one mile to the northward of Pulicat light-house. In heavy flood years several subsidiary bars may open—at the present time, one such minor bar is open, situated near the head of Karimanal inlet.

The shores of the lake are everywhere low and sandy, the vegetation scanty, save where casuarina and palmyra plantations have been made. Contrary to my expectations I found mangroves conspicuous by their scarcity, the only ones seen being in a shallow bay on the east side of Kurivi Thettu, a low swampy islet east of Irakam. At the extreme north the lake degenerates into a long expanse of salt marshes now partially cut off by a low embankment called Dyke's Bund.

The main section of the lake is divided into an eastern and a western division by the interposition of two long islands, Venadu and Irakam, lying in a north and south line. To the eastward of the islands the lake is very shallow and virtually dries up in seasons whenever the bar remains closed during April and May; the lake to the west is deeper and as a consequence boat traffic and fishing confer comparative prosperity upon this side. A peculiar and extensive industry, that of digging sub-fossil shells for lime-burning from a shell-bearing stratum some four feet below the mean sea level, exists everywhere along the foreshore of the western and southern margins of the main section of the lake, and on Venadu and Irakam islands. Piles of these old shells gleaming snowy white in the sun are among the most familiar objects seen when travelling along the west coast line; in some places as at Sunnambukulam and Arambakkam a line of disused shell pits have been connected to form what is now a serviceable little canal through a dreary waste of pitted foreshore.

The shells excavated from these pits throw most valuable light on the past history of the lake. At Sunnambukulam and Arambakkam, now at the extreme south-west or innermost corner of the main section of the lake and distant twelve miles from the present sea coast, a large number of the shells belong to genera and species which either do not live in the lake or are of rare occurrence, as *Cardium*, *Dolium*, *Fusus*, *Sanguisorba*, and *Placuna*. These do not however occur all at the same horizon, and *Placuna*, it is worthy of note, lies at a superior level to the others named. Most of these shells are the same as we may now collect any day on the sea coast near the bar.

Reconstructing in barest outline the past history of Pulicat lake with the aid of these shells and a knowledge of the

conditions now existing in more or less land-locked bays which are not true backwaters, *e.g.*, Tampalakam bay in Ceylon, Tuticorin bay in South India—it would appear that when the earlier deposits containing *Cardium*, *Dolium*, and *Fusus* were forming, the area now occupied by the lake and by much of the low land to the west was part of the open sea. Shallow water conditions prevailed and the appearances indicate that deltaic deposits of great extent were contemporaneously in course of formation. By the drifting of this sand and silt along the coast by monsoon action, northwards most probably, a long sand spit, gradually extending and growing, would tend to form, creating such a partially protected bay as we now see at Tuticorin, but of vastly greater extent. This open bay condition may be termed the second stage in the lake's history. For a long period, as counted by years, little change took place in the fauna; *Cardium*, *Fusus*, *Dolium*, *Sanguisorba*, *Turbinella* (chank) and other shallow water marine molluscs lived on in the sands, cockle beds being particularly well populated. By degrees as the protecting spit grew in length and strength, it gave greater quietude to the waters of the bay; silt instead of being carried to the deeps settled in increasing quantity in the bay and cockles and other sand-bank animals began to find their environment increasingly unfavourable and gradually died off. By this time the bay had become more or less landlocked by the extension of the natural breakwater formed by the spit, and this stage, characterised by muddy bottom and as yet an unimpeded tidal condition of its waters, is the third in the history of the lake. It was at this period that *Placuna* supplanted *Cardium* and other sandy bottom molluscs. It may have been towards the close of this phase that the Dutch settled at Pulicat as the town now nearly a mile inland is said to have been situated on the sea coast in Dutch times (J. H. Taylor in G.O., No. 293, dated 7th June 1883).

The present condition of the lake represents the penultimate stage characterised by the reduction of the depth of the lake to a condition of extreme shallowness and the virtual blocking out of free tidal flow. The landlocked bay has become a lake liable to be closed for months to the sea, subject to extreme differences of level due on the one hand to excessive evaporation over an extensive shallow area and on the other to the accession of enormous volumes of flood water unable to drain away unless they burst a way through the weakest part of the sand embankment which impounds the waters of the lake. The reduction in salinity caused periodically by these floods has made the lake unsuitable for the continued well-being of *Placuna*, so the beginning of this stage witnessed the virtual

disappearance of this mollusc. The inner or landward portion of the lake now harbours no species of molluscs except small gastropods which live along the water's edge; what exist elsewhere (*Ostrea*, *Mactra*, and *Arca rhombea* are examples) live within a radius of some two to three miles from the bar where the salinity of the water is better maintained and dryage of the lake less extreme.

The final phase will probably be characterised by the complete canalisation of the lake and the gradual reclamation of all the area not utilised for drainage and flood channels and traffic waterways.

Depths of water and periodic closure of the bar.—As mentioned above I ran a large number of lines of soundings across the lake, and for reference append details * of the more important.

During the period of inspection (August) the sea bar was open and the levels subject to a limited tidal influence averaging a difference of about one foot between high and low tides. So far as possible the soundings were made at half-tide and may therefore be taken as representing the mean level of the lake under normal tidal conditions, and when no flood water is pouring in.

Omitting the dredged boat-channel maintained by the canal authorities along the east side of Pulicat island, the only section of the lake with depths of one-fathom and upwards is the narrow channel which extends westwards from the vicinity of the bar and separates Karimanal from Pulicat. Off the south end of Karimanal, depths up to 14 feet are obtained. From this point the channel curves to the north hugging the Karimanal side at first and then bends west till about midway between the Karimanal shores and Annamalaicheri. Here the greatest depth becomes reduced to $5\frac{3}{4}$ feet. Further north this channel, becoming further reduced in depth, widens very extensively to form a great area to the west, south, and south-east of Irakam carrying depths varying between 4 and $4\frac{3}{4}$ feet.

Between Venadu island and Tada (west shore of lake), the deeper water does not run to more than three feet, while east of Venadu, $1\frac{1}{2}$ to 2 feet of water is carried practically the whole way across to the east shore, Zonangipalayam and neighbourhood. The northern and main section of the lake thus forms two well marked divisions, (*a*) an eastern, characterised by such shallowness of water as to permit of no traffic worth

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* Omitted for the present.

consideration and liable to be more or less denuded of water periodically, and (b) a western division, carrying depths of 3 to $4\frac{1}{2}$ feet over the greater part of its area. Marginal shallows carrying one foot and less of water are greatly in evidence along the south coast, from Sunnambukulam to Mankodu and thence to Annamalaicheri; also from off the latter village southwards to Pulicat North Island. All along these sections of the lakeshore, light-draft fishing boats have to be moored to poles driven into the mud at distances of from $\frac{1}{4}$ to $\frac{1}{2}$ mile from land on account of this extreme shallowness of water.

The shaded sketch plan appended shows graphically these several points.

The levels described above represent the lake under normal conditions; during the monsoon season, from October to December, when two-thirds of the annual rainfall occurs, the water level tends to rise considerably and whenever a closure of the bar coincides, the flood level may rise several feet above the normal. Conversely, if the bar remains closed during an exceptionally dry season, April to June, the lake acts as a huge evaporating basin and has been known to fall $3\frac{3}{4}$ feet below mean sea level (May 1891); reference to the sketch plan will show how greatly reduced the water surface of the lake becomes at such a time, the shrinkage entailing the drying up of between 60 per cent. and 70 per cent. of its normal area.

Unlike the majority of bars on this coast south of the Suvarnamuki river, that at Pulicat does not close annually. Hitherto its closure has been on an average once in five years. The year of closure usually occurs when the bar has shifted to the extreme north end of its run and is stopped from further progress in that direction by increase in the height of the beach.

Whenever this occurs a considerable head of flood water is required during the north-east monsoon to scour deeply the channel of the bar or to form a new breach at the south end of the run. With a bar at the extreme north end and weak monsoon floods, conditions which appear to coincide approximately every fifth year, a closure of the bar is certain in the ensuing hot weather.

Within recent years the bar closed in 1890, 1895 and 1905.

An outline of the history of the first of these closures may be considered as typical of the series; as Russell, in his "History of the Buckingham Canal Project," pages 26–27, gives an excellent account of the consequences, I prefer to

quote his own words in full rather than attempt to paraphrase or condense them. He says:—

"The sea bar of the lake closed during July (1890), and the water level of the lake never rose, during the next north-east monsoon, sufficiently high to burst open the bar, the north-east monsoon being unusually scanty, and the great extent of the flood waterspread making the lake act as a moderator of floods. From the time the bar closed in July 1890 up to February 1891, the lake remained at a fairly high level, and slowly passed off the floods received into it, during the north-east monsoon, by means of the canal, to the open bar of the Ennore backwater, mile 10 north of Madras and to the open bar of the Dugarazapatam backwater, mile 70 north of Madras. By March 1891, however, the lake had run down to a comparatively low level, and the hot weather evaporation soon caused such a steady drop in water level that, when early in April the bar of the adjoining Ennore lake began to contract, the surface water level of both the Ennore and Pulicat lakes began to fall in a very ominous manner. From 13th to 24th April, the general water level dropped 0·80 foot. On the complete closing of the Ennore bar on 24th April and the consequent final cutting off of all supply from the sea, tremendous evaporation at once set in over the extensive surfaces of both lakes, and promptly caused a steady and continuous flow of water from the open reaches of canal in communication with each lake. This evaporation registered about one inch in depth per day, and traffic, which was very heavy at the time, was, in a fortnight, altogether stopped, notwithstanding that the utmost exertions were made, by means of the rapid execution of heavy clearances unparalleled in the history of the canal, and extending for over 60 miles in length, to cope with the rapidly dropping water level. At the same time, measures were taken to open and keep open both the Pulicat and Ennore sea bars by running out long groynes to sea on the southern, or windward, side of the site selected for opening. Finally, after some three weeks' labour, both the bars were artificially opened by the inrush of the sea at high tide; a heavy scour was obtained through them; the bars remained open for about six weeks; the water level in the canal reaches rose rapidly, and the water level in the Pulicat and Ennore lakes rose steadily, until the bars of those lakes closed. Both operations were entirely successful, and all trouble in the canal was at an end as soon as the bars were opened. An idea of the drop of water level by evaporation in the backwaters, before the sea bars were opened, can be formed from the fact that, in the interval of four weeks that elapsed between the closing of the Ennore bar and the reopening of both that bar and the Pulicat bar, the general water level in both the Pulicat and Ennore lakes, and in a long length of canal, dropped over 2 feet, the gauge register at the Shadayankuppam lock (7 miles north of Madras) falling during this period from — 1·36 M.S.L. to — 3·76 M.S.L. At the Kondaleru river, mile 90, where the bar was open, and for some few miles south of it, the tides rose and fell as usual and traffic could proceed; but from mile 70 to the Pulicat lake, and southwards to the Shadayankuppam lock every sea bar was closed during this period of four weeks; the canal contributed a steady flow of water to the backwaters to make up for the loss of evaporation

in them, and the general surface water level was a plane inclined at an angle to the backwaters into which the respective portions of canal were draining."

A repetition of abnormally low levels in the lake occurred in 1896 consequent upon the closing of the bar during the hot weather of the preceding year; in this case, however, although the bar remained closed for a longer period, the lowest level recorded, 2·66 feet below mean sea level in August 1896, was higher by a foot than the minimum of 1891. With shrinkage on the scale denoted by even the lesser of these instances the appearance of the lake becomes entirely changed from what it is under the normal conditions prevailing now. Instead of a vast and continuous sheet of water extending from Karimanal across to Annamalaicheri and thence north-west to Tada and north to Kasuba kuppam, a great plain of salt encrusted mud occupies almost the whole of the area between Venadu and Irakam Islands on the one side and the Buckingham canal on the other; on the west of Venadu were it not for the softness of the mud, one could walk across to Tada with water never reaching above the ankles. West and south of Irakam a considerable area of shallows carrying from 1 to 1½ feet of water remains. Elsewhere the lake becomes reduced to a narrow and relatively deep canal extending westwards from the closed bar, past Karimanal and thence northwards to join the shallow expanse south and south-east of Irakam Island. Within the bounds of this deeper channel gather the whole of the large fish remaining in the lake, making heyday for the fishermen.*

Whenever the lake closes during the hot weather season, the canal authorities carefully note the rise in level during the ensuing north-east monsoon; as soon as the lake rises to one foot above highest spring tide, means are at once taken to open the bar by cutting through the sandbank which has closed its mouth. If the cut be completed at low tide, the head of flood water pouring through the opening scours a deep passage, which thereafter is kept open and deepened by successive floods and by the scour of the ebb tide.

Should the monsoon rains not be heavy, the flood level of the lake may never rise sufficiently high to give the requisite

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* In passing it is worth noting that in the dry season of 1905 when a similar concentration of fish occurred in the remaining deeps, it is said that a party of West Coast fishermen arrived with a large seine and swept the contracted waters of the Pulicat and other similarly shrunken backwaters, netting within a few days immense quantities of fish and securing great profit. Opposition to this action was overcome by gifts of some of the small fish caught and the enterprising strangers were gone before the local men came to realise that their lake or backwater was depleted of large sized fish.

head required for an effective scour; in this case nothing further can be done to open the bar till the following year when in May we have the coincidence of a low level of the lake and high tides in the sea without. Under such conditions the bar may be *temporarily* opened from the sea side by taking advantage of the head of water provided by a high spring tide and by building a groyne on the windward side of the projected opening to check accumulation of sand and to direct more effectively the scour of the first tidal water that enters the lake. Such an operation is at once more costly and less effective than when the opening be made in the reverse direction. It may even fail entirely and at all times requires great care and judgment to carry out successfully. The whole operations which cost over Rs. 5,000 are of temporary benefit only, as the bar closes again by silting within a period varying from six weeks to two months owing to the lack of flood-water scour to counteract the silting tendency of the southerly winds and current.

Shrinkage of the water-level on the extraordinary scale seen at periodical intervals in Pulicat lake, associated as it doubtless is with a notable increase in salinity, exercises naturally a most baneful influence on all sedentary life, plant as well as animal, within the normal limits of the lake; if the lake organisms be not dried up upon the general recession of the water, they are almost certain to be killed by the excessive salinity of the water in the pools remaining or by the excessive heat to which they are exposed. Only in the deep channel near the bar can there be comparative safety.

If the dangers associated with an abnormal fall in the water-level be survived, life within the lake finds another danger in the great height to which floods may swell the lake and reduce salinity far below the normal. Fortunately the area of its water-spread is so extensive that it can absorb and distribute a great volume of flood water without a marked rise in level. Unless the monsoon rains be particularly heavy, the rise in the lake level is gradual and does not ascend much above highest spring tide level when the bar is closed. As the water became super-saline during the process of drying up during the hot season, so the flood water of a moderate monsoon has the effect of bringing salinity back to the normal.

In exceptionally wet years when very heavy rain falls continuously for days together, the moderating influence of the great area of the lake is overcome and the level steadily rises until such time as the head of water becomes so powerful as to force open the bar or till an artificial cut through the beach hastens this event. With the attention now given to ensuring

the early release of flood water from the lake, the high flood levels of former years are not likely to be repeated. The highest flood level recorded is 8½ feet above mean sea level, a height which signifies that the volume of water in the lake has been increased to at least four times the normal; that to the one volume which represents the normal have been added three volumes of fresh (sweet) water. As the specific gravity of the lake is not more than 1,030 under ordinary conditions the addition of three volumes of fresh water will reduce it approximately to 1,008, a reduction sufficient to prove fatal to many animals which might otherwise find suitable life-conditions within the bounds of the lake, *Placuna placenta* in particular, a mollusc living to-day in the adjoining sea, and partial to muddy bottom and land-locked bays.

Nature of the lake bottom.—Fine quartz sand and an extremely smooth dark mud, greyish black to full black in colour, are the two main constituents of the bottom.

Above high-tide level the shore is very generally composed of clean yellow sand, but except for the bar channel and the shoals adjacent, subject to a heavy daily tide-scour, the bottom consists either of fine mud or of sand and mud in varying proportions. East of Pulicat, in Karimanal inlet, in the shallower water between Karimanal and the Annamalaicheri side and generally along the lake shore for varying distance from high-tide level, sand occurs mingled with mud. Pure mud, soft and oozy, forms the bottom everywhere else, that is, in all depths greater than one foot below mean sea level, except in the neighbourhood of the bar.

In the muddy sands in the vicinity of Pulicat, as also in Karimanal inlet, considerable numbers of bivalves are found, usually in distinct beds; as a consequence, the lake bottom in these sections contains in places a considerable admixture of dead shells. In the mud deposit of the deeps, shells of any kind are seldom seen—no molluscs live in this mud when it is of any depth; as it is now, it forms one of the most barren and valueless bottoms imaginable, the only life supported being a scum of diatoms particularly abundant wherever the water is very shallow.

Salinity and temperature.—Both density and temperature are high as may be inferred from the physical features of the lake. The former is influenced by the enormous area of shallow water exposed to rapid evaporation, by the slight influence of the tidal wave away from the immediate vicinity of the bar, and by proximity at the north end to salt marshes and salt impregnated strata.

The specific gravity and temperature of seven main stations upon the lake, taken during August 1908, were as follows:—

Locality.	Depth.	Hour.	Specific gravity.	Temperature.	
				Water.	Air.
				F.	F.
Off Pulicat town	2 feet ..	8 A.M.	1,027·50	82°	84°
Channel near Karimanal lock ..	3 ,, ..	5 P.M.	1,027·50	85°	84°
Off Sunnambukulam	2 ,, ..	2-30 P.M.	1,031·00	89°	90°
Off Bimaripalayam	2 ,, ..	9 A.M.	1,033·00	83°	85°
Half way between Venadu and Tada	3 ,, ..	8 A.M.	1,033·00	84½°	85°
Tada	2 ,, ..	8 A.M.	1,039·00	83°	84°
North end Irakam Island ..	1½ ,, ..	8-30 A.M.	1,035·50	82°	81°
West side Venadu Island ..	1 foot ..	3-30 P.M.	..	95°	96°

From the above table it is seen that the specific gravity for some distance from the bar is that of normal sea water for the temperature registered.

As distance from the bar increases, the specific gravity mounts higher with marked regularity—1,031, 1,033, and 1,039—the last and highest reading being at Tada at the north-west extremity of the lake, a place adjacent to a large series of salt marshes and salt pans. Inshore at the north end of Irakam, another high reading was obtained, 1,035·50, higher indeed than that in mid-channel further north, 1,033, between Venadu and Tada. This is due probably to mid-channel water being subject to greater tidal influence than the inshore body of water. The relatively great frictional resistance offered by the bottom in the marginal shallows tends still more to render the inshore body of water considerably more inert than that in mid-channel.

Much greater density than the highest now recorded must prevail during the hot season whenever the bar is closed; no records taken during such period appear to be in existence and we must wait till the next recurrence of these conditions to obtain the needful data. Conversely, when floods are on, especially with the bar shut, the density must be greatly reduced in ratio according to the amount of dilution of the normally somewhat super-saline water of the lake.

Never was there any marked difference in temperature between the lake water and the air in shade. As will be noticed the temperature ran fairly high; August 27th was an abnormally hot day, the air temperature being 96° F. in the shade while the water was but one degree lower (95° F.), the highest salt-water temperature I have ever recorded.

III.—The Possibilities of Oyster culture on simple lines in Pulicat Lake.

Excellent oysters exist in fair quantity and of good size in the several localities in Pulicat lake already particularized; under present conditions large stretches of suitable bottom in shallow water are available for oyster culture by simple and inexpensive methods and, were we reasonably sure that existing favourable conditions will continue, no difficulties of importance would bar the way to very extensive cultural operations and output. We have noted, however, in considerable detail the occasional (periodic) extreme oscillations in level to which the lake is subject—how at intervals of some five years the shallows, which *present* conditions indicate as alone suitable for oyster-culture, in great part dry by recession of the water-level. No means are practicable to avert this periodic catastrophe. Therefore if oyster-culture be attempted in Pulicat lake it must be under limitations. Two plans are possible, which may be tried either separately or simultaneously. The first is to limit the culture to those places which we may reasonably assume will never dry even in years of extreme drought; the second is to utilize the shallows, which dry up periodically, by arranging to plant them with brood oysters, as quickly as possible, after one of the catastrophic years, and to harvest the crop within the ensuing four normal years, which usually intervene before the cyclic return of a year of exceptional drought shall temporarily convert these shallows into dry land.

This latter system of carrying on oyster-culture has the hall-mark of Nature to attest its feasibility and its reasonableness. The evidence is clear that when last the lake partially dried up most of the oyster beds were left high and dry by the receding waters with the consequence that the bulk of the oysters died off from exposure to the sun and from lack of water. Very few survived but these were sufficient to repopulate the beds when the floods came to restore the lake to a normal level.

It appears to me extremely probable that the spawning season of Pulicat oysters coincides with the onset of floods in October and November. If so, at the end of a period of low levels in the lake all the exposed old oyster shells will become clean and bright by the combined action of sun and rain by the time they are once more submerged by the rising waters and will form the best possible kind of cultch for swimming oyster-spat to settle upon. It will be remembered that I laid emphasis upon the fact that with the exception of one deposit, the oysters in each bed examined were of identical age throughout that bed. There must be, at least, annual production of

spawn from each bed but it appears that ordinarily no suitably clean cultch is available to attract fresh spat. Only when some of the adult oysters now living shall die off in the next great drought will suitable cultch be provided to meet the taste of the swimming spat which must have clean surfaces for attachment or they will die without making attachment. Shells covered with mud and diatom slime are valueless as cultch; at the present time practically all the oysters now alive in Pulicat lake are in such condition.

If this method of oyster-culture be adopted, additional area may be obtained by planting up the muddy shallows with mangroves and by inducing oyster spat-falls upon the stilt roots thrown out by these bushes. In some districts mangrove oysters are of considerable economic importance; the culture is most simple and it would have other advantages. At present the mangrove is all but absent from the lake; its introduction would help to accelerate the silting up of the muddy shallows east of Venadu. It would in this way reduce the area of the water-spread of the lake at its shallowest part and so reduce that excessive evaporation which in dry seasons brings about all the difficulties resultant from the partial drying up of the lake. Yet another advantage would be the supply of large quantities of bark for net-tanning which would be thus provided for the fishermen—mangrove cutch being probably the best barking material known for nets. Its collection and preparation form a considerable industry in Burma and in Borneo. In passing I may also mention that I have seen mangrove purposely planted along the shores of a muddy bay on the north coast of Kattiawar to furnish supplies of firewood.

Karimanal inlet is the only place where continuous culture is possible. Receiving more tidal water than any of the other localities where oyster beds are situated, its oysters may be expected to show the best growth; against this advantage is to be set comparatively limited area. The west side only is available for culture, the east side being exposed to silting and shoal movement in consequence of the manner in which the bar shifts gradually from the south to the north end of its run during the years it remains open.

If culture be worked in three to four-year periods, all oysters save a large breeding reserve in deep water being harvested just before a closure of the bar, then the area available is of very considerable extent—not less than ten square miles at a moderate estimate.

The most suitable plan of operations would probably be to prepare by liming a great quantity of cultch—old oyster and

cockle shells, and bricks and tiles, entire or broken (Pulicat is full of ruined brick buildings), during the period when the bar is closed and the level of the lake falling. When the shallows off Pulicat, Karimanal and Annamalaicheri become dry or nearly so, and not much further shrinkage is expected, the prepared cultch should be spread over the firmest and cleanest area available and left there till the expected floods arrive to stimulate the reproductive glands of whatever oysters survive and induce spawning with consequent spat-falls upon the collectors laid down if conditions prove favourable.

Fascines or bundles of casuarina twigs might also be tried as spat-collectors, these being anchored preferably in the deeper water section of the lake. The culture of mangrove oysters would entail greater initial expense as mangrove seeds would have to be obtained and planted. Extensive planting, if successful, would have such far reaching beneficial effects by reducing the extent of the shallowest portion of the lake and by forming a barrier to overflow northwards of flood water, that it may prove desirable eventually to offer some special inducements in order to encourage this method of oyster farming. For a long time however the cultivation of mangrove oysters by private individuals will not come within the range of practical politics; it must wait until oyster-culture in the shallows by means of shell, brick, and fascine spat-collectors has been proved successful and profitable. Meanwhile it would be distinctly useful and appropriate if an experimental planting of mangroves be taken in hand by the Fisheries Department with a view to ascertain the species best adapted to suit the purposes in view under the peculiar conditions existing in the lake.

If systematic cultivation of edible oysters be taken up extensively, culture of the magnificent pearl-producing green mussel (*Mytilus smaragdinus*) would probably follow, as its natural association is with our local oyster. In the Sonnapur river in the Ganjám district where they are, or were till recently, fished for the pearls contained, there exists a distinct *Ostrea-Mytilus smaragdinus formation*; indeed the same association is noticeable in the Ennore backwater though less emphatic owing to the smaller extent and the relative sparsity of the oyster population.

These large mussels are actually more highly esteemed in India than are oysters; they form an excellent main ingredient in curries. In Malabar and Travancore there exists an extensive fishing industry in the collection of mussels for this purpose, an industry that serves as a training school for a hardy race of divers, hundreds of whom are accustomed to

cross to Ceylon whenever a pearl-fishery takes place there. Dried, these mussels will find a ready market in China, and for this may prove more useful than oysters, as the bodies are firmer and more bulky than those of the latter. If put up in a tasteful manner in tins they are also likely to find a ready market. The pearls occasionally contained would also form a source of some profit to the culturist; they lie nearly always close to the surface of the mantle and would be readily discernible during the preliminary preparations for either tinning or drying; they may be removed at this stage without difficulty and without detriment to the prepared product.

Combined culture of oysters and mussels is therefore to be recommended, particularly as the only needful preliminary would be to provide a sufficient number of mature mussels to serve as "breeders". From these the needful spat would arise to populate the oyster beds. With increased experience special mussel spat collectors might be found desirable, but in the beginning no such device appears requisite.

Arca (? *rhombea*) exists in considerable numbers especially in the Karimanal inlet and its culture on Japanese lines may be feasible if oyster farming be capable of successful conduct.

ENNORE,
22*nd September* 1908.

OFFICE OF THE REGISTRAR OF BOOKS.
REGISTERED
23 JUN 1910
MADRAS.

NOTE

ON

AN ATTEMPT TO ASCERTAIN THE PRINCIPAL DETERMINING FACTOR IN OYSTER-SPAWNING IN MADRAS BACKWATERS

BY

JAMES HORNELL, F.L.S.

In a report dealing with the results of a biological survey of Pulicat lake made in August 1908 with the main object of ascertaining the suitability of this largest of Madras backwaters for the culture of the edible oyster, I arrived at the conclusion that "it is extremely probable that the spawning season of Pulicat oysters coincides with the onset of the floods in October and November."

2. It has been noted by observers that the spawning season of oysters in European countries and on the eastern seaboard of the United States is correlated with the marked rise in temperature which occurs in shallow waters along the coasts of such latitudes during the summer months, particularly in June and July; Dr. H. F. Moore of the United States Bureau of Fisheries states indeed that oysters do not begin to spawn on the Atlantic and Gulf of Mexico coasts till the temperature of the surrounding water reaches about 70° F. (not less than 67° F.), that it may be assumed that on the gulf coast a heavy discharge of spawn rarely, if ever, takes place much before May 1st, and that spawning in all probability is practically completed by the first week in August. In France, at Arcachon and Auray, spat-collectors are seldom placed in position before the middle of June, the beginning of July being the usual maximal spawning period.

3. In India conditions differ in many essentials; the temperature of shallow waters scarcely ever falls below the minimum of 67° F., while during May to September it seldom registers less than 80° F. often rising as high as 90° F., yet I was unable to see any evidence that spawning occurred freely during

these months. As a consequence I was led to look elsewhere for some other factor capable of imparting an adequate stimulus to the nerve centres controlling the emission of the reproductive products, and, as already stated, at the end of my inspection of the oyster-beds at Pulicat I arrived at the conclusion that the chief determining stimulus has little or nothing to do with variation in temperature in the case of Southern India, whatever it may have in the north, as for example on the oyster-beds in the neighbourhood of Karachi; rather did it seem to me a question affected by differences in the density or specific gravity of the water bathing the beds. It appeared to me that so far as the oyster-beds on the East Coast are concerned the spawning maximum synchronizes with the earlier portion of the heavy rainfall period of the north-east monsoon which begins normally about 15th October and lasts through November. At Madras, where the meteorological conditions coincide closely with those prevailing over the chief backwater on the East Coast, the average over 80 years * shows that the total annual rainfall is distributed as follows:—

	INCHES.
During the first 5 months of the year, January to May	4·50
During June to the end of September ...	15·00
„ October	11·00
„ November	13·25
„ December	5·25
Total for year ...	49·00

4. To test the accuracy of this theoretical deduction, I arranged last September, before leaving on an extended tour on the West Coast, for the conduct of an experiment with spat-collectors in the Ennore backwater to extend through the rainy season of October and November. The material selected consisted of ordinary curved "country" roofing tiles. These were given a preliminary coating of lime (ordinary slaked lime stirred into a bucket of sea-water to a creamy consistence) and then in some cases given a second coating of 1 of lime to 3 of sand. The tiles were made into small bundles of six rows of two tiles each, the alternate rows at right angles to those above and beneath, and with the concave surface downwards in all cases.

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* *Vide* Russell in "History of the Buckingham Canal Project," Madras, 1898.

The bundles were secured with wire and I left instructions with the Superintendent of the experimental station to place two bundles at weekly intervals in the shallow water of a small area of the backwater, previously selected and enclosed, lying immediately eastward (seawards) of the fisheries station.

5. These spat-collectors were accordingly placed in position on the following dates: 23rd and 30th September, 13th, 22nd and 29th October, 5th, 12th, 19th and 26th November, 3rd and 8th December. On my return to Ennore on 12th December I examined the whole of these collectors and it was extremely gratifying to find that a very satisfactory set of spat was clearly in evidence. Unfortunately, owing to a number of the bundles not having been marked so distinctively as they should have been, it was found impossible to distinguish between the different lots laid out in October, but this is of comparatively little importance as all the October lots were thickly covered with spat.

6. So far as the individual bundles could be identified, the following are the results:—

Lot 1, two bundles of collectors, laid out 23rd September.—Only an odd spat of small size and apparently of recent attachment adhering here and there upon the tiles in these collectors; the surface fouled greatly with fine muddy sediment.

Lot 2, laid out 30th September.—The majority of the tiles in these two bundles bore no spat, more particularly those of the lower rows; a few oysters were found on the upper tiles and the majority of these were of a particularly large size, ranging downwards from $1\frac{3}{8} \times 1\frac{7}{8}$ inch. There were several between $1\frac{1}{2}$ and $1\frac{3}{4}$ inch in diameter, those uncrowded being almost circular in outline. The census of oysters on the tile carrying the largest individual is as follows:—

Under or concave surface—

		Depth.		Length.	
1	of	4·70	×	4·70	centimetres.
1	of	3·60	×	3·90	,,
1	of	2·75	×	3·30	,,
1	of	2·70	×	3·40	,,
1	of	2·25	×	3·35	,,
1	of	3·35	×	2·20	,,
1	of	0·50	×	0·50	,,
1	of	0·40	×	0·40	,,
Total ... 8					

On the upper or convex surface a number of very small ones appeared :—

		Centimetres.
9 being between		0·50 × 0·50.
	and	0·40 × 0·40.
1 of		0·80 × 0·75.
1 of		0·95 × 0·80.
1 of		0·90 × 0·75.
1 of		1·50 × 1·90.
1 of		2·10 × 2·10.
1 of		2·10 × 2·60.
15		

The concave surface bore in addition a large number of barnacles (*Balanus*) and 21 serpulid tubes averaging from 1·75 to 2·00 centimetres in length ; on the convex side there were but few barnacles but along the margin at one end was a considerable quantity of short green conferva.

The total oyster population on this tile was 8 individuals above 2 centimetres in diameter and 15 under this size, the dimensions of the tile, like those of all the others, being 9 inches by 6 inches approximately.

The characteristics shown by these tiles put down on 30th September were the presence of a small number of young oysters of large size ranging from $1\frac{1}{2}$ inch to $1\frac{7}{8}$ inch in diameter and a larger number of small ones of half an inch in diameter and under, but even these were not numerous.

Lots 3, 4 *and* 5 *laid down on the* 13*th*, 22*nd and* 29*th October*.—These six bundles having their identity confounded have to be treated as one lot. This however does not appear to be of great consequence as they all appear equally thickly covered with spat, so much so that the spat crowd one another to such an extent as to cause contortion and an outturning of the edges at right angles to the plane of the body. On this account it is impossible to measure the length and depth accurately, but an approximation of the average of the size which predominates is 2·50 × 2·70 centimetres. Taking two tiles from different bundles, we counted 43 oysters on tile A, varying between 2·70 × 2·70 centimetres and 2 × 2 centimetres, the majority inclining towards the larger size ; on tile B the number of those ranging between these two sizes was 35. In both cases there were a few of still smaller sizes, 17 in the case of A, and 23 in the case of B ; these ranged down to ·80 centimetre × ·80 centimetre. On A there were one *Anomia* 2·20 centimetres in diameter, a few small barnacles, serpulid

tubes and crusting calcareous polyzoa, also two young *Mytilus* ·4 and ·5 centimetre in length, respectively. On B were 3 *Anomia* averaging 2·25 centimetres diameter. Barnacles on this tile were very scarce and quite tiny, but crusting polyzoa was abundant and had interfered with the growth of several of the smaller oyster spat.

On A the whole of the 60 spat were located on the concave side of the tile; in B out of the total 58, 43 were on the concave side, 15 on the convex. No observable growth of algæ had occurred on either tile, but the concave surface in both had a somewhat dirty appearance due to the roughness of the surface caused by the crowding and distortion of the young oysters.

Lots 6, 7, 8 *and* 9—5*th to* 26*th November.*—On none of these was there any considerable set of spat. A typical tile selected at random gave the following census:—

24 on the concave side, 9 on the convex. Of the former, the largest was 1·90 × 1·90 centimetre; the smallest 0·65 × 0·60 centimetre. Between these extremes there was a perfect gradation. Of barnacles there were 22 of about ·3 centimetre across; no serpulids and no *Anomiæ*, but of crusting polyzoa there were three colonies, the largest being 3 centimetres in diameter.

Lots 10 *and* 11 *of* 3*rd and* 8*th December* appeared perfectly clean and were put back into position again.

7. Summarizing the results, it appears that spawning did not take place till the very end of September or the beginning of October, as the collectors put out on 23rd September bore only a few odd spat of quite small size; those tiles apparently became fouled before spawning took place, and only recently became scoured clean here and there, allowing of the attachment of an occasional larva.

The great number of spat of more or less the same age on the collectors laid out in October point to this month marking the maximum or rather the optimum of the spawning activities of the adult oysters in this locality; alongside of the density of set in October, we see a diminished set continuing until December as shown by lots 6 to 9 laid down in November. In this connection it must be noted that in this particular Indian species as in the American *O. virginica*, the ova pass several days in a swimming stage before sinking to the bottom and making attachment. Any that attached for instance on 25th October were spawned probably about 20th October and so with all other attachments.

8. Now what were the conditions during these months? When I left Ennore on 23rd September, the backwater as it had been for the year preceding had no opening into the sea, and the rains had not commenced on the coast, although the level of the backwater had shown signs of rising. A few days after I left heavy rains were experienced and during October the backwater rose rapidly and so high that to relieve the pressure of the flood in the Buckingham Canal which crosses the backwater, steps were taken by the Public Works Department to cut a channel from the backwater to the sea. On 25th October when the flood level had risen three feet above the level at which it stood on 23rd September, the cut was made, the head of flood water rushing through to the sea with such violence that a deep channel was formed with the result that from that date to the present the backwater has remained tidal. This access of a great volume of fresh water poured into the backwater during the three weeks preceding 25th October very greatly reduced the density of the water and this taken in conjunction with the fact that the October laying of spat-collectors was the one marked by the best set of spat obtained is strong evidence that this rapid reduction in the density of the surrounding water was the stimulus requisite to stir the adult oysters in the backwater into sexual activity—the emission of milt or spermatozoa in the case of the male and of ova ready for fertilization in the case of the female. A heightened temperature certainly was not the cause, as the temperature of the water *before* the onset of floods was higher than during their continuance.

9. The experiment, imperfect as it admittedly is—I was absent during the whole time it was being conducted—proves two points of the greatest interest :—(*a*) that the maximum sexual activity of the edible oyster of the East Coast rivers and backwaters synchronized with the heavy rains of October and November, October being apparently the optimum; (*b*) the exceedingly rapid rate of growth indicated for our Madras oysters. It also furnishes very strong evidence in favour of the view that a rapid reduction in the density of the surrounding water and not an increase of temperature as in European and American waters, is the factor which determines the season at which the majority of oysters shall spawn.

10. With regard to the rate of growth of oysters; in France the spat which attaches to collectors, say in the first week of July, is not detached till October, a period of at least three months, and by this age it is not larger than the thumb nail, at the outside 1·80 centimetre or about ¾ inch in diameter.

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Growth in England and Holland is considerably slower, while in America, whereas South Carolina oysters take 6 to 7 months to reach a length of $2\frac{1}{2}$ inches, in the warm sounds of North Carolina, they reach a length of $1\frac{1}{2}$ inch in from two to three months.* In our experiment the rate of growth is considerably better than any of these except perhaps that of North Carolina, as we have seen that between 30th September and 12th December or within $2\frac{1}{2}$ months they attain a length of $1\frac{7}{8}$ inch, while if we assume, as I think is fair, 22nd October as the mean date for the fixation of the spat attached so closely to the collectors laid out between 13th and 29th October, then these oysters by the 12th December or in the space of $1\frac{3}{4}$ month, reached a length of $1\frac{1}{16}$ inch or 2·7 centimetres, a rate twice and a half more rapid than that considered satisfactory in France.

11. Altogether the experiment is most satisfactory in its results; it has shown that the collection of spat can be carried out by the simplest of means and at a very low cost; it has demonstrated conclusively the rapid rate at which growth progresses and confirms my conclusion arrived at by other reasoning during my survey of Pulicat lake, that the Madras oyster will attain an excellent marketable size within $2\frac{1}{2}$ years, possibly even within two years.

12. In conclusion it is interesting to note that the local oyster of our backwaters, which I believe to be identical with that of Ceylon backwaters, and which has been identified as *Ostrea cucullata*, is more closely akin to the oyster of the east coast of America, *O. virginica*, than to the French and English native. The appearance and form of the shell and the habit of growth agree so closely with the characteristics of the American species, that the two seem little more than geographical races of one species, just as the pearl oyster of our coasts occupies the same position towards the so-called species of the Gulf of Mexico, the connection of the Gulf of Mexico with our own seas being, indeed, much closer biologically than are the seas of Europe.

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* Moore "Oysters and Oyster culture." U.S. Fish Commission Report for 1897, Washington, 1897.

ENNORE,
2nd January 1909.

PLATE.

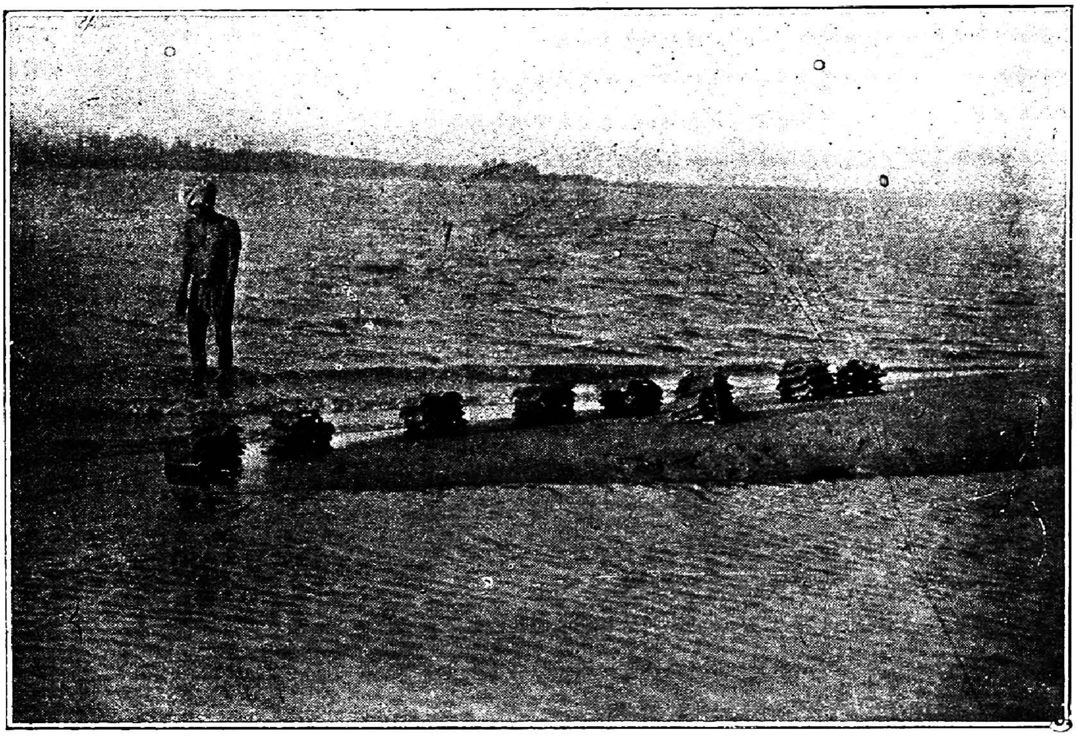

FIG. 1. TILE COLLECTORS IN ENNORE BACKWATER COVERED WITH OYSTER SPAT DEPOSITED DURING THE FLOODS OF OCTOBER 1908.

FIG. 2. COLLECTING EDIBLE OYSTERS OFF CANNANORE BY MEANS OF DIVING.

Note the small raft-buoy carrying a wand to which are tied small bundles of betel, etc., for the diver's refreshment between dives.

[*Photo. J. Hornell.*]

REPORT

ON THE

FEASIBILITY OF OPERATING DEEP-SEA FISHING BOATS ON THE COASTS OF THE MADRAS PRESIDENCY, WITH SPECIAL REFERENCE TO THE SELECTION OF FISHING CENTRES AND HARBOURS OF REFUGE,

BY

JAMES HORNELL, F.L.S.

[Three plates.]

The advantages likely to accrue to the fishing industry from the introduction and extended use upon the coasts of the Madras Presidency of larger sized fishing boats from 10 tons register and upwards in size, have been so exhaustively detailed by Sir F. A. Nicholson in two reports to Government (February 1906 and May 1908) that it is superfluous to do so here.

2. It will suffice therefore if I recapitulate the four heads under which these advantages have been grouped in the papers referred to.

They are four in number, and are as follows :—

(*a*) To take crews safely and comfortably into the further waters of the fishing grounds and to allow them to stay there for some days, following and catching the shoals ;

(*b*) to allow the use of better and more powerful nets and lines ;

(*c*) to save time, to lessen the number of hands, increase freedom of action, and to permit of the use of mechanical appliances to save labour and increase efficiency ;

(*d*) to enable means to be taken by the fishermen to ensure the proper preservation of fish from taint from catch to shore.

3. Mr. Sullivan Thomas in the Proceedings of the Board of Revenue, 21st August 1886, No. 1887, has also stated his opinion that the principal means to arrest an assumed growing scarcity of fish on the Madras Coast is the same remedy as has been applied in England, viz., "to have better appliances,

that is to say, much larger nets and more seaworthy boats and to go further to sea." But whilst among those who have studied the subject a consensus of opinion exists that the introduction of larger boats with the ability to employ nets of greater dimensions than those now in use is necessary if there is to be any considerable increase in the prosperity of our fisheries, there has been some divergence as to the practicability of employing such boats, at least upon the East Coast. Mr. Sullivan Thomas pointed out the lack of any harbour of refuge on the Madras coast line to which fishing boats might run for shelter in a storm, and the special danger from cyclones to which a fishing fleet would be exposed in consequence of this deficiency.

4. To gain reliable data to enable this doubt to be resolved prior to taking final steps to settle the type of fishing craft most likely to prove suitable for the peculiar local conditions which have to be faced, Sir F. A. Nicholson deputed me recently to make an examination of the shore line both on the East and West Coasts of this Presidency. Up to the present date I have completed a survey of the coast extending over practically the whole sea-front of South Canara and Malabar on the west side, while on the east I have visited all points and ports of importance between Cape Comorin and Pamban, and from Point Calimere to the Penneru river, 90 nautical miles north of Madras. I shall try to state the essential facts and conclusions brought out by the enquiry as succinctly as possible, but giving such details of the various ports and estuaries as may be of permanent value for reference purposes.

5. Varying physical characters in the coast line have necessitated corresponding divergence in the types of fishing craft hitherto employed. Four distinct coast sections are linked with four such types of fishing craft in the districts I have examined, two being of major and two of minor importance. These coast sections may be distinguished respectively as—

(*a*) The catamaran coast,
(*b*) The dhoney coast,
(*c*) The boat-catamaran coast,
(*d*) The canoe coast.

6. (*a*) *The Catamaran coast.*—Wherever heavy surf breaks on a long stretch of open coast unbroken by any shelter-giving headlands, the form and handling of the catamaran have been brought well nigh to perfection. In the effective simplicity of its design, in the safety with which it can be launched and

brought ashore through the wildest surf, in the ease with which its parts may be taken apart and carried up the beach and afterwards reassembled, the catamaran is certainly the most serviceable craft for use on a surf-beaten coast. For 250 miles south of Madras and for a considerably greater distance to the north, practically no other craft is employed in fishing; the larger ones carry three or four men each and are furnished with a well-barked permanent sail of fair proportions.

No notable headlands break the monotony of the coast line from Point Calimere to long past the Penneru; the only available harbours excepting Madras, are those formed by the estuaries of the larger rivers, and of these a large proportion become useless for the greater part of the fine weather fishing season, the south-west monsoon period, owing to closure of the bars brought about by the silting action of strong longshore currents running northwards acting concurrently with a cessation of river flow, the consequence of drought. Between Madras and the Swarnamukhi river, 60 miles north of Madras, the estuaries of all the rivers and backwaters are liable to close during the hot season, and even when they do remain open the depth of water over the bars is too low to prevent of ready ingress and egress in the case of boats of several feet draught; north of the Swarnamukhi river all bars remain open continuously, but so far I have been able to examine two only, the Kandaleru and Penneru rivers. The former estuary, 70 miles north of Madras, constitutes the old harbour of Kistnapatam, a place of considerable importance in the coasting trade till the rise of the Buckingham Canal and the completion of the coast railway diverted traffic into new channels. Thirty years ago it was the port of Nellore and native craft of considerable burden, and drawing as much as 9 feet of water, entered the river for repairs, the repairing sheds being situated along the margin of the deep water lying west of the present forest bungalow; the estuary itself is of ample depth, in places over 25 feet, and has excellent road communication with Nellore, 17 miles distant. In 1883 it was credited with having a depth of 11 feet of water on the bar at high spring tides.

The condition of the river at the present day is somewhat less favourable; on the occasion of my visit, which coincided with high water of a spring tide, the greatest depth on the bar was $7\frac{3}{4}$ feet; as the range of tide is from 3 to $3\frac{1}{2}$ feet, at low tide $4\frac{1}{4}$ to $4\frac{3}{4}$ feet would be the best water available. Apart from this, the position of the river mouth may be said to be permanent, while the estuary is less liable to silting than any other on the Coromandel Coast. A mud bank formerly existed off this port (I do not know whether it still remains), and it

is interesting to read in G.O., No. 293, June 1883 (Marine), that, when His Excellency the Governor landed in 1878 at Kistnapatam in order to visit Nellore, this mud bank gave effectual protection to the steamer "Khandalla" from the violence of a cyclone which came on while the steamer was awaiting His Excellency's return and which was very severely felt from Madras to Masulipatam. Captain Taylor, the then Master Attendant of Madras, in relating this experience says "I remained at anchor in the 'Khandalla' upon this mud "bank and though the sea was unusually high outside, and "the centre of the storm passed very near, bursting on the "coast at Ongole, and doing great mischief, we did not experi-"ence any discomfort, the sea being reduced to a long lazy "swell."

Between the Kandaleru and Penneru rivers, the Kodur river, Gangapatam backwater and Nallateru river enter the sea, but as their bars are open only intermittently after floods, they are valueless as fishing boat centres.

7. The next place examined was the mouth of the Penneru river, 90 miles north of Madras. This river is one of considerable size and its bar never closes. Unlike the Kandaleru, the river mouth is not always in the same place, and at times of flood there may be several openings; this lack of concentration renders the scour of floods much less effective than it should be and as a consequence the river estuary (or backwater) is very liable to silting. In many places in the channel where I sounded at about low tide on 16th September 1908 the depth was as low as 2½ feet. On this day at one hour before high water the least depth on the bar was 5 feet, which should give 6 feet at high-water. In spring tides at least another foot should be available or a total of 7 feet against the 9 feet in 1883 which Marshall gives in his "Handbook of Directions to the Ports in the Presidency of Madras." As already mentioned the position and formation of the bar are unstable; sometimes there is but one opening to sea, sometimes several. On the day I visited it, the width of the single mouth was too great to permit of a good scour and the best channel over the bar was of considerable length, passing for some distance parallel with the shore between two lines of surf. A rather heavy surf extended a considerable distance seawards, as though there were a lengthy stretch of shoal water off the entrance to the river.

Altogether the bar appeared somewhat "ugly" and not one that I should feel safe in attempting in any fishing boat other than a catamaran. It may well be that at other seasons the bar channel is shorter and more favourably situated; that

would but emphasize the lack of stability which appears to be a characteristic of the entrance to this river. In passing, it is interesting to note that the fishermen and others with whom we conversed were unanimous in stating that the depth of water in the river was formerly greater than at present and that the volume of flood water—the prime agent in scouring deeply the channel and the bar—has greatly lessened since the anicuts at and above Nellore were constructed. The same cause is operating in most of the East Coast rivers, a decreased volume of water and lessened scour, owing to the making of anicuts. An instance in point is the rapid deterioration of Cocanada harbour after the completion of the anicut over the Gódávari at Dowlaishweram and the silting up of the mouths of the Tambraparni after a similar construction of anicuts upstream. With the progress of irrigation works and increased cultivation under such systems we may look for a still further reduction in the volume of water in the terminal sections of the East Coast rivers with the result that river ports will still further deteriorate.

Northward of Penneru there are several harbours which may probably be found very suitable as fishing centres, notably Masulipatam and Cocanada, but with these I have no personal acquaintance.

8. Taking a survey of the coast southwards of Madras we find no harbour of any fishery value till we reach Cuddalore. Covelong and Sadras which lie between, were both once the centres of considerable trade but at present have no importance, Covelong bar being closed nearly the whole of the south-west monsoon. During this season there is, however, good shelter for small boats in the small bay to the north of Covelong point and for half the year it may be safely used as a boat anchorage. Cuddalore is well situated to serve as a fishing centre; the river bar though not a deep one is not dangerous, the trading importance of the place is sufficient to ensure efforts being made whenever exceptional shallowing takes place, while rapid transport of catches is assured by the proximity of the railway; a siding runs down to the quay wall where fishing boats would discharge. The bar has been at times troublesome, sometimes through silting, at other times by change in its position. But in spite of all this the place has never intermitted its importance since the East India Company opened a factory here and built Fort St. David in 1683. At present the depth of water on the bar is seldom more than 6 feet at spring tides, with a mean range of about 3 feet. About 150 lighters belong to the port; most of these are about 10 tons register, but there are a few decked lighters of 25 tons

drawing between 2 and 3 feet. The draft of cargo boats is usually restricted to 2 feet as on this they are able to cross the bar at any state of the tide in fair weather. Native craft of 200 tons and drawing 5 feet occasionally enter the river at high water for repairs.

At present comparatively little fishing is carried on as the Patnavar Chettiar who form the fisher caste here get such regular and well paid wages as boatmen that they prefer such work to the uncertain remuneration and hard life inseparable from the fishing industry as now carried on. Still men in plenty are available to man fishing boats if regular wages or other equal inducement offer.

9. Porto Novo at the mouth of the Vellar river and about 14 miles south of Cuddalore has almost equal advantages with the latter port. On the day I visited the harbour very little surf was breaking on the bar; the channel over was easy with about the same depth of water as upon the Cuddalore bar. A small quay convenient for the rapid handling of cargo is situated half a mile above the bar and about two miles by road from the railway station.

On the date of my visit two channels over the bar were in use, one, the more direct, used by the smaller lighters, the other and longer which runs northwards instead of directly eastwards, by larger craft. Several coasting vessels were laid up in the river, among them a brig of 150 tons waiting a good spring tide to cross the bar. Fishing craft drawing 3 feet should be able to enter the river at high water every day throughout the year, while if they draw 6 inches less they should be able to enter at almost any hour except dead low water. One great advantage which Porto Novo has as a fishing centre is that the roadstead or anchorage off the port enjoys excellent shelter in southerly winds owing to the large shoal off the Coleroon river which breaks the swell. The bottom is mud and affords good holding ground. Until of late years Porto Novo was much frequented by native coasting craft; the gradual opening of the coast railway and the competition of Cuddalore have combined to divert traffic and Porto Novo in its present melancholy state of decay, like so many towns on this East Coast, is evidence of the frequently baneful local effects entailed by that centralization in commerce which has been one of the most marked changes wrought by the introduction of steam.

10. The 86 miles of coast from Porto Novo to Point Calimere, is one monotonous stretch of low sandy land presenting a straight front to the sea. At frequent intervals streams and rivers intersect it, nearly always with a town or

fort bearing a name of historic interest at the mouth. Devicotta, Tranquebar, Karaikal, Nagore, and Negapatam are the chief of these and, save in the case of the last named, are subject to the same causes of decay which have robbed Porto Novo of its prosperity.

The Coleroon opens some 4 miles south of Porto Novo and if the bar were navigable the broad river within would form a most magnificent harbour. As it is, the river opens into the sea over a wide shallow bar on which the surf breaks heavily for a considerable distance owing to the shallowness of the sea in the immediate vicinity. Much silt is brought down during floods, forming extensive shoals seaward of the entrance ; the tendency of the river mouth to move northwards is very pronounced.

11. Tirumalavasal, 13 miles north of Tranquebar, is the next port to be reached. One of the branches of the Cauvery discharges into the sea near the town, but like the mouth of the Coleroon, this entrance is somewhat variable. A fair amount of trade is carried on chiefly with coasters which lie off the port and are served by a number of cargo boats which cross the bar into the river to load. At low water a depth of 2 to $2\frac{1}{2}$ feet of water is found on the bar at the times when it is open. During the last of the hot weather the bar usually closes, reopening as soon as the monsoon floods arrive. In regard to accessibility the river is rather better than that at Negapatam, but scarcely so good as at Cuddalore or Porto Novo.

12. Tranquebar, once the busy port of the principal Danish settlement in India, comes next in order in our progress down the coast. At the present day sea-borne trade has practically abandoned the port, and the river is scarcely ever used by coasting craft.

For specially designed shallow draft fishing boats the bar presents no particular difficulties, while the river within offers snug shelter. During the greater part of the year the bar carries about 2 feet of water at low tide, with 4 to $4\frac{1}{2}$ feet at high water of spring tides. A considerable number of hardy fishermen live outside the town and do a large curing trade at certain seasons, helped substantially in this by the proximity of the large salt factory maintained by Government at this centre. These men in common with other fishermen between here and Negapatam already have some acquaintance with deep-sea fishing and have already experienced the need for larger and more stable craft than their ordinary three-log catamarans. I found that from the end of May to

the middle of August the fishermen of this coast make long journeys to the deep-sea in search of flying-fish, which at this season are usually met with off this coast in great abundance. As these fish seldom go far landwards of the margin of the *Kala pani*, the fishermen have to prepare to go, if need be, out of sight of land. This they regularly do, but to cope with the heavier seas met with at such a distance from land, large craft are temporarily improvised by tying seven specially large catamaran logs together. In this way a deep-sea catamaran is contrived capable of accommodating a large catch of fish and of carrying a small quantity of food and water. Each of these catamarans is said to carry a crew of eight men. Usually they leave shore at 6 o'clock in the morning reaching the fishing grounds by 3 P.M. If shoals of flying-fish be seen, a satisfactory catch, enough to load the boat, is usually made within two to three hours; at sunset, whether or not a good catch has been made, they cease work and return shore-wards reaching home early the next morning if the wind favour them. It is worthy of particular note that if no shoals be met with before sunset, the men start for the shore at this hour; catch or no catch, the open nature and the smallness of their craft entail return within 24 hours if such be humanly possible—no man will willingly face a longer period of such exposure and confinement as the use of a catamaran entails, to say nothing of the inability to carry food and water for a longer period. Often these men return starving and worn out and yet without a single fish as reward for the privations they have endured. Such men, I believe, would welcome the introduction of sea-going and sea-keeping boats, which would enable them to stay, if need be, days together at sea. Indeed as will be mentioned later, Negapatam men have taken this step recently and point the way for further development.

I should add, before leaving this subject, that instances were brought to my notice where men engaged in this fishery have been actually on the verge of starvation because of excessive delay in reaching shore owing to head winds. On some occasions the men have been unable to reach home for three whole days, being driven well nigh to Pondicherry before they could make the shore.

Altogether Tranquebar offers many advantages as a fishing boat centre; a fisher population inured to hardship and already practically conversant with deep-sea fishing is already established there, curing facilities are first class owing to the proximity of a salt factory, the river would give shelter to the fishing fleet in rough weather while the railway from Porear Road at Karaikal, 6 miles away, provides the requisite facilities for distribution.

13. *Karaikal.*—This small French port would also make a good fishing centre. The river mouth seldom closes (it did in May 1905) and that its bar offers no obstacle to light draft traffic is evidenced by the numerous cargo lighters which load cargo at neat wharves within the river to carry to the steamers of the British India and Asiatic Steam Navigation Companies which call off the port fortnightly. The railway station is within a quarter of a mile of the cargo wharves.

Nagore and Negapatam.—These twin ports are situated within five miles of each other, Nagore being this distance to the north of Negapatam, which is 222 miles by rail from Madras.

Negapatam is by far the most prosperous port between Point Calimere and Madras, but this is in spite of considerable natural difficulties. As a harbour Negapatam is inferior to several of the ports so far enumerated, and keeps its trade chiefly because of the conservatism of business men (otherwise "vested interests") and the support given by this being a terminal railway port. Of recent years the river entrance has steadily deteriorated, causing continual anxiety and trouble, more especially during the months of January and February when there is considerable danger of the bar closing entirely. In February 1907 and January 1908 the entrance was 400 feet south of the jetty and had only 6 inches of water over it at low water of spring tides. From February to October or November no greater depth than 12 to 15 inches can be reckoned upon at low water, with a rise of from 2 to 2½ feet at springs. During such time traffic over the bar is possible only for a limited time before and after high water, sometimes (as in May 1905) for one hour only before and after. As a consequence the cargo boats here are of comparatively small size, ranging mostly from 8 to 10 tons register. The dimensions of one of the larger are: length 45 feet; beam 8 feet 7 inches; depth 5 feet; burden 10 tons in fine weather.

It is interesting to find that the deterioration of this river entrance is an instance of the harm which may be done to a harbour by the reduction for irrigation purposes of the volume of water in the river which produces the scour requisite to keep the bar navigable. In the present instance a diversion of the river Vellaiyar was made some years ago by which its stream was prevented from joining the Kaduvayar of which the mouth forms Negapatam harbour; as a consequence the floods in the river were reduced and the bar scoured less deeply than in previous years. At the present time I understand that steps are being taken to return some of the diverted water with

the hope that the increased head of water may rectify the harm occasioned.

Taking it as it is now, Negapatam affords good anchorage outside the river, but is valueless as a port of refuge. Any fishing boats using it will do so only on account of its value as a distributing centre ; they must go elsewhere for shelter—either to Nagore to the north or southwards to Thopputturai or to the south-west of Point Calimere—an arrangement which would be found probably quite satisfactory as well as practicable.

14. Negapatam fishermen like those of Tranquebar and Nagore go to some distance beyond the 100 fathom line of soundings during summer in search of shoals of flying-fishes and have the same custom of improvising specially large catamarans for this particular fishery. This year (1908) an innovation in methods was made which is most significant and satisfactory to those who urge the need of larger boats for the proper development and conduct of our fisheries. For the first time on record cargo boats or lighters this summer were fitted up as fishing boats and used in the flying-fish fishery. The pioneer boat of the enterprise caught over 80,000 fish in one day and this so excited the native traders of the town that eventually twelve out of the 70 available lighters belonging to the port (apart from the fleet owned by the Madura Company) were engaged in the fishery. For the most part the crews were recruited from the ranks of the port boatmen, 6 to 7 men to each boat.

As much as Rs. 200 to Rs. 300 each was taken by some of the boats for a good day's work, the boats returning home daily. The total quantity of fish caught must have been very great; one trader informed me that he himself purchased 10 lakhs of the dried fish for shipment to Rangoon, Penang and Singapore. It is also eaten locally and considerable quantities are despatched to Tanjore. Preparation of the fish consists in it being opened longitudinally, eviscerated, washed in sea water and sun dried; no salt is used.

If adverse winds be experienced the catamarans are sometimes so much delayed that the fish becomes putrid and has to be thrown overboard. However it has to smell very badly indeed before the men proceed to this extremity. Even if two days old on landing, they will yet attempt to cure it! Here most assuredly the services of a swift carrier attending to a group of boats working at sea for several days together, would be most valuable.

15. *Nagore.*—This town, situated on the river Vettar, is now a considerable distance from the point where the river

debouches into the sea. As a haven for small craft the river is considerably superior to that at Negapatam as the depth of water on the bar is seldom less than 2 feet at low tide, the mean range of springs being 2½ feet. In the north-east monsoon the depth is greater and ships of 200 and 300 tons burden used to enter the river at that season and undergo repairs in mud docks. On September 29th when I visited Nagore, there was little surf on the bar and three schooners were in the river, ranging in size from 50 to 60 tons, the crew of one busily engaged in making ready for sea.

As the fishermen of Nagore are comparatively numerous and as many of the Lubbais who form a preponderating section of the population are well provided with money, the principal elements are present to make Nagore a thriving fishery port once the utility and profit of sea-going fishing boats be demonstrated.

16. *Velanganni*, a large Roman Catholic fishing village, located at the mouth of a creek some 6 miles south of Negapatam, is in quite as bad a condition as its larger neighbour. During the hot weather there is seldom more than 6 to 12 inches of water on the bar at low tide, putting it out of count when in competition with places such as Nagore and Thopputturai.

Thopputturai is a rising port a few miles north of Point Calimere. Like all other harbours on this coast it lies at the mouth of a small river differing chiefly in that it is more suitable for boat traffic than most others. At low water there is said to be seldom less than 2½ feet of water on the bar. A number of dhoneys of 20 to 30 tons belong to this port, which affords excellent shelter during the south-west monsoon. Altogether it is a very good harbour for shallow-draft craft and as a fishing boat centre during the south-west monsoon.

17. *Point Calimere* would form an excellent location for deep-sea fishing boats. There is no harbour and no need of one, as boats may anchor under the lee of the land to the northward of the point during the south-west monsoon, and to the west and south-west of it during the north-east monsoon. If the necessity for shelter be urgent they may run for refuge to Thopputturai harbour. Fishing boats using the neighbourhood of Point Calimere as their base would have the option of two rail ports at which to land their catches, Negapatam during the south-west monsoon and Adirampatam during the north-east.

18. With Point Calimere my review of ports on the catamaran coast from the Nellore district southward ceases. We have seen that within this extent of 330 miles of coastline,

the number of available harbours suitable to shelter fishing craft is very limited in the northern section and consists only of Kistnapatam and Madras, while in the southern section we have a very satisfactory array—Cuddalore, Porto Novo, Tirumalaivasal, Tranquebar, Karaikal, Nagore, Thopputturai and Point Calimere, with Negapatam as an additional working centre during fine weather. Of course the best harbour of all is Madras, where neither surf nor shallows ever obstruct the entrance and where shelter from even the violence of a cyclone is afforded by the boat basin. Next in value come Point Calimere, Thopputturai and Negapatam worked in conjunction, with Porto Novo and Cuddalore not greatly inferior.

I am inclined to recommend that Tranquebar be tried as the head-quarters of the first experimental deep-sea fishing boat during the flying-fish season which lasts from June to August inclusive, especially as this port is the most suitable centre for the investigation of the Tanjore chank fishery.

II.—The Dhoney Coast ; Muttupet to Tuticorin.

19. From Muttupet to Tuticorin coastal conditions alter completely ; the dreary monotony of a straight-line coast disappears, bays and headlands become numerous, breaking the sea-front and furnishing shelter in varying degree to fleets of small native craft. This section of the coast falls naturally into two sub-sections, a northern forming roughly three sides of the shallow sea known as Palk Straits, and a southern forming the western boundary of the head of the Gulf of Mannar. The two parts differ considerably. The coast line of the northern one affords comparatively little shelter except at the northern and southern ends, where the ports of Muttupet and Pamban are respectively situated. The southern sub-section on the contrary possesses some of the safest and best harbours, Madras excepted, within the bounds of the Presidency. In great part this is due to the protection afforded by a chain of islands which stretch intermittently parallel with the coast from Tuticorin to Pamban, supplemented by the shelter given against northerly winds by the general east and west trend of the shore line. Sometimes as at Tuticorin and Pamban the islands close in to the south to form true harbours of refuge, equally safe whether the south-west or the north-east monsoon be blowing; at others as at Kilakarai the islets approach each other sufficiently closely on the seaward aspect as to form an effective breakwater parallel with the shore so that vessels may approach the port either from the eastward or the westward. Indeed from about 8 miles west of Kilakarai right on to Pamban the chain of islands is so effective that the passage within is recognised as a safe channel for vessels

plying between Kilakarai and Pamban even when the south-west monsoon is at its worst. Pilots conversant with the intricacies of this inner channel, as it is called, are officially recognised but seldom employed as few vessels save local craft pass this way at the present day.

As a direct consequence of the excellent shelter afforded at frequent intervals along this coast, several types of small sea-going craft, as distinct from larger trading craft such as brigs, schooners, and barques, have arisen at various centres, Muttupet, Pamban, Kilakarai and Tuticorin, each distinguished by special features designed to meet special local conditions or particular requirements. These in several instances require comparatively little modification to fit them to become excellent fishing boats for deep-sea work ; as it is they all are capable of crossing to Ceylon and of taking part there in the pearl fisheries of which the scene of operations may lie as far as twenty miles distant from the fishing camp and often involves stormy experiences. The boats and men from Pamban, Kilakarai and Tuticorin form the backbone of the Ceylon fishery, while a few quaint Muttupet craft are never awanting. Except the Kilakarai contingent, these boats are seldom or never used for sea fishing, but their existence is a factor of the greatest importance when we contemplate the introduction of fishing craft designed to fish, if need be, far from land and capable of keeping the sea for days together. As it is, the rig and build of some of these boats approximates wonderfully closely to what is characteristic of modern Scotch herring drifters. Both use forms of that most useful of sails, the lug—in one the lateen, in the other the dipping lug—and were the Pamban boat to have more beam and the Tuticorin lighter to have less heavy lines, these boats if decked would pass muster as very serviceable fishing boats in the waters of Northern Europe.

20. A few details of the principal havens under notice may be useful for further reference.

Muttupet and Adirampatam are situated 20 and 30 miles respectively westward of Point Calimere. Both are subject to the same disabilities so that particulars of Muttupet will suffice for both. This town lies some seven miles up the winding river Korayar and is a large settlement of the Lubbais, who here trade largely with Ceylon. The carrying craft are principally native schooners and brigs of considerable tonnage, which on account of the extreme shallowness of the sea, generally anchor several miles from shore. The boats by which cargo is conveyed to these vessels have long journeys to make and have to combine the handiness of river boats with sufficient

stability to face monsoon winds some miles out at sea, especially as with southerly and south-easterly winds a heavy sea sets into the bay of Adirampatam. The combination is a difficult one to achieve and the type of boat that has evolved is like many compromises—a result that is far from satisfying to the critical mind though practically it may be and probably is the best result possible pending, say, the introduction of shallow-draft motor lighters, which would be a boon to shipping at this port were it not that sailing vessels the world over and in India in particular seldom appreciate that time is a synonym for money in commerce.

The Muttupet type of fishing boat is much longer and narrower than that of the cargo boats and is built on the lines of a canoe, so that in calms and headwinds it may be propelled by paddles with fair speed and a minimum of exertion. Three masts are stepped, the fore and mizzen masts extremely short, the main considerably longer; the sails are small square sails good enough for running before the wind, but not very serviceable in beating to windward; for this, reliance is placed upon their numerous paddles; they are really rowing canoes of great size fitted with masts and sails to enable them to take advantage of favouring breezes. They offer no assistance in the problem before us save that they serve as training schools to a considerable body of men who would readily adapt themselves to the handling of fishing luggers.

Adirampatam fishing boats differ in having one mast only; a long balance board or outrigger projects on either side. Plate I, figure 1, depicts the peculiarities of this essentially local type.

Ammapatam and Tondi.—These ports lying on the western coast of Palk Straits are open roadsteads; they appear too exposed to form suitable centres for moderate draught fishing boats but I am unable to write definitely as this is one short stretch of coast line I have not yet been able to visit.

21. *Pamban*, with which must be included Mandapam on the mainland, is remarkable for having produced a type of boat running from five to fifteen tons, more nearly akin in build and rig to North European design than anything else in India. Its use was primarily to ferry pilgrims bound for the great shrine of Rámésvaram across the Pamban Pass, the narrow strait separating Rámésvaram island from the mainland. The wind seldom serves both ways and a long series of short tacks is often necessary—the outcome of which necessity has wrought such a modification of the lateen sail as to give the Pamban rig a close approximation to the handy fore and aft rig seen so highly

PLATE I.

MADRAS FISHING BOATS.

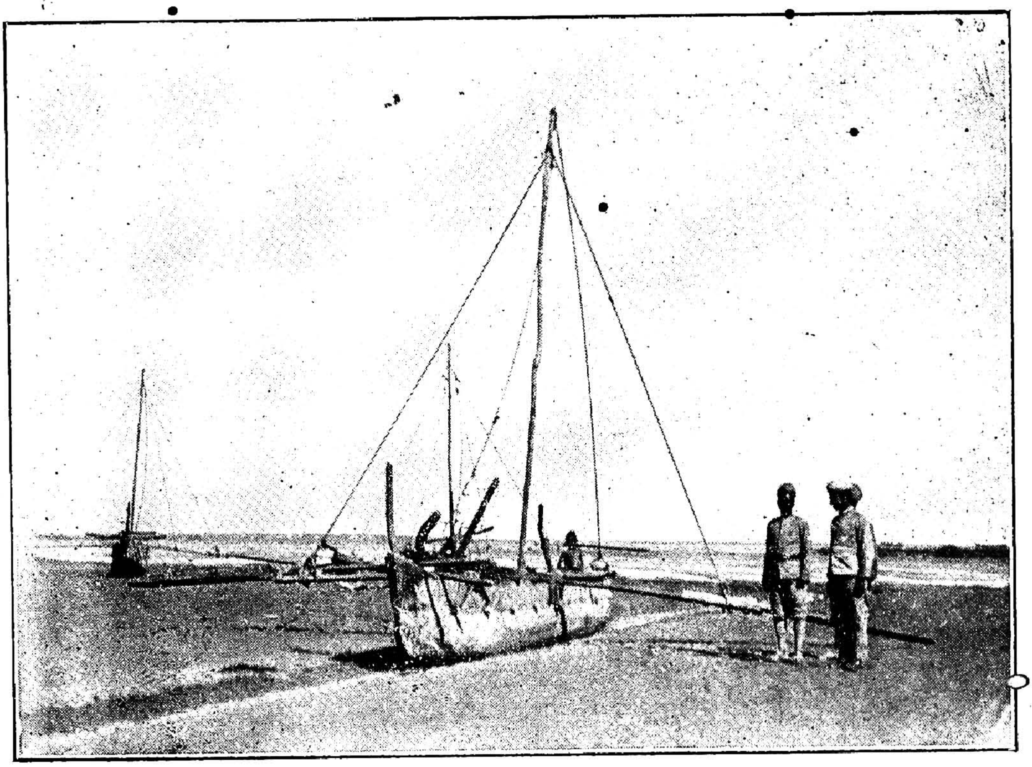

FIG. 1. ADIRAMPATAM FISHING BOATS.

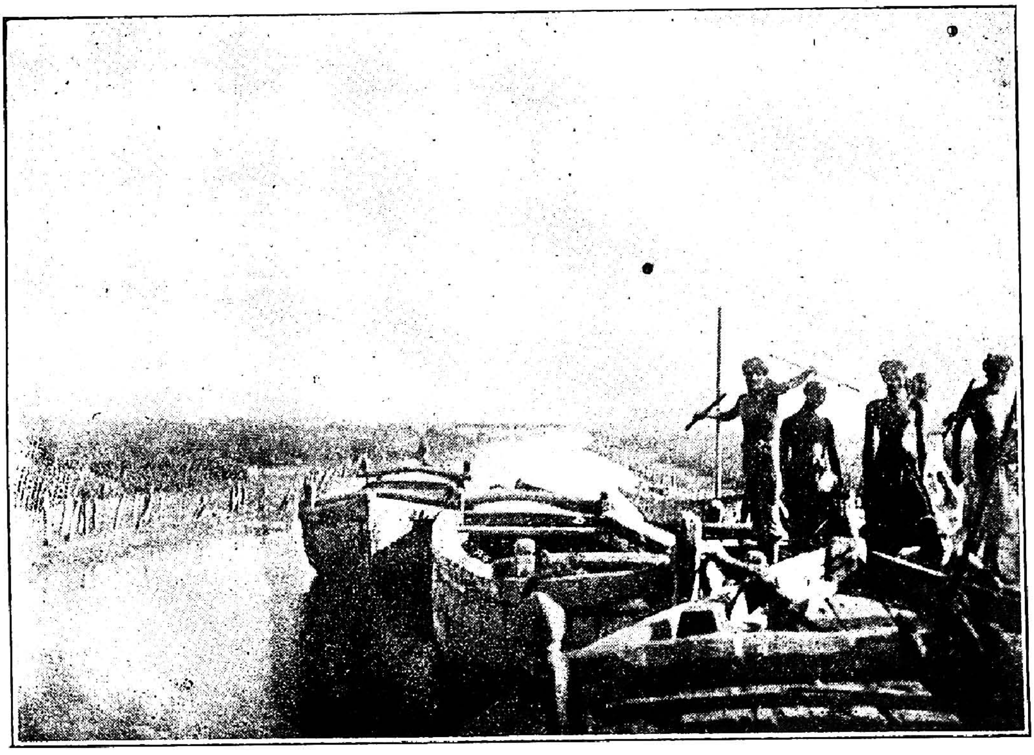

FIG. 2. ADIRAMPATAM CREEK. CARGO LIGHTERS IN THE FOREGROUND.

[Photo. J. Hornell.]

developed on the Norfolk coast and at the oyster centres of Kent and Essex, where in the one case the configuration of the banks, and in the other the necessity to beat backwards and forwards across a limited dredging ground, require a similar quickness and handiness in going about.

The smaller Pamban boats carry a single mast bearing a handy lateen lug sail, the larger ones favour a small mizzen similarly furnished; both invariably possess a good jib. Both stem and stern-post are straight, the stern always square and in this differing from the sharp stern seen in the boats of Tuticorin, Kilakarai, and Jaffna (Ceylon). The difference is probably due to the necessity to keep down length in boats having to work through such a narrow and winding channel as Pamban Pass.

22. The dimensions of two of the smaller Pamban boats are as follows:—

	A.	B.
Length	30′ 5″	33′ 8″
Beam	7′ 5″	7′ 0″
Depth	2′ 9″	4′ 0″
Draft loaded, about	2 0	3 0
Tonnage	5 tons	7-55/130 tons.

One of the larger boats, a 16 tonner, when fully laden drew slightly over 4 feet on an inside depth of 5 feet. From the low free-board allowed it is seen that they are boats intended for work in protected waters; it is true they often make comparatively long voyages, they are often to be seen in Tuticorin harbour or lying at anchor in the roadstead off Negapatam; they also attend the Ceylon pearl fishery in large numbers, but such voyages are coasting trips with several snug shelters along the route. To make these boats safe for deep-sea fishing a considerable addition to their beam would be necessary with some little increase in depth and better lines aft. With these modifications such an improved Pamban boat would be able to carry an increased spread of canvas and should prove a useful deep-sea fishing boat. Nothing in rig requires altering.

As a harbour of refuge Pamban or rather Mandapam is unequalled by any port in India. During the south-west monsoon a fishing fleet would enjoy perfect security on the northern side of the Mandapam promontory and of Rámésvaram island, during which time the boats would have the whole of Palk Strait and Bay for the field of their operations, while

during the north-east monsoon they would ply their work in the then considerably sheltered waters of the Gulf of Mannar with a splendid harbour under the lee of Kandugal Point.

As a distributing centre Pamban should prove most favourable now that the South Indian Railway Company has a terminus at Mandapam; from there the rich centre of Madura is reached in a little over five hours, while if the 9–25 A.M. train from Mandapam be caught, fish can be delivered at Trichinopoly in time for dinner, or if fish be sent by the 1–45 P.M. train from Mandapam, it will reach Madura at 8–5 P.M., Trichinopoly junction at 3–5 A.M. and Tanjore at 4–55 A.M. With regular supplies of good fish guaranteed by the work of even a few staunch sea-going fishing boats, distribution should be highly profitable both to the enterprising middleman and to the Railway Company. Regular supplies, ice, enterprise, and organization are the desiderata.

23. *Kilakarai.*—This port, a stronghold of sea-faring Lubbais, is well sheltered by several islands which lie some five miles seaward and act as a natural breakwater. Sailing vessels of fair size lie at anchor off the town in safety the whole year round. It may be considered a fully satisfactory haven for fishing boats of several feet draft, the great drawback being lack of good land communication with Ramnad and the railway. Indeed the last thought in the mind of a Kilakarai man is land transit; shut off by the worst of roads from the neighbouring inland towns, he never thinks of going anywhere except by water. He begins life by splashing and diving in the shallows and graduates through the chank fishery to the proud day when his father recognizes his manhood by taking him as a fellow diver to a pearl fishery. But pearl fisheries unfortunately are not annual institutions, and during the intervals the divers of Kilakarai divide their time between chank diving and sea fishing. The chanks fished by these men lie either in Palk Bay or to the north and north-east of the Jaffna Peninsula. A favourite resort for net fishing during the south-west monsoon is the neighbourhood of Thanishkodi at the east end of Ráméswaram island, so that what with the Ceylon pearl fishery, the Jaffna chank fishery, and seining on the Rámésvaram coast, the Kilakarai fisherfolk may justly lay claim to be considered the most enterprising fishermen in the Presidency. Among them are numerous wealthy men of influence—the chief pearl oyster merchant at a pearl fishery usually hails from here, the present lessee of the Ramnad Chank fishery is one of them; they are sober, saving folk, given perhaps to an over-fondness for the star pagoda but the more useful on that account if they can be persuaded of the value of deep-sea

fishing and of an improved and larger type of boat for its prosecution. The boats at present used at Kilakarai are of a distinctive type particularly interesting as they evidence once more that within limits the fishing community of the East Coast of Madras is an enterprising and adaptative body of men; I believe that up to the present day the fishermen of this part of the country, so far as local limitations imposed by peculiarities of the coastline will permit, have kept full pace with the times, that is with the demands made upon them to supply fish to the neighbouring communities; what has checked progress has been lack of the means to ensure distribution beyond a few miles from the coast. The advent of railways affording rapid transit to large inland centres of population has suddenly changed conditions, but even yet difficulties and inexperience in knowing how to keep fresh fish wholesome during transit, fetters the situation. But to return to the Kilakarai type of boat, it differs from every other in the world as it has been evolved to suit the very special conditions associated with the pearl and chank fisheries. The boat must provide accommodation for a considerable number of divers working together. Above all, as the pearl and chank fisheries can be carried on only during the finest season of the year, when light winds and dead calms are frequent, boats designed for this calling must be readily and quickly moved from point to point as each in turn is exhausted of shells. Hitherto paddles alone have been available, hence the boats of Kilakarai are built long and narrow to allow five divers to work on either side if need be, and to facilitate frequent change of anchorage in the search for a rich section of the bank.

The rig is of the simplest consisting of a single mast, stepped nearly amidships, on which is set a primitive looking cotton square sail. So long as the wind is steady and not over violent these boats make an excellent pace; to counterbalance their inherent lack of stability a long balance or outrigger board is run out amidships on the weather side and weighted with from 2 to 5 and even 6 men according to the strength of the wind. Several times I have seen three-fourths of the crew of one of these boats squatting or standing on the outer end of the outrigger board. A big lee board is always carried and is often in requisition as the boats are built without keel. So well adapted are they to the special requirements of pearl and chank fishing that it is unlikely the type will be readily exchanged for another; more likely will it be that if the merits of another type be demonstrated for say drift netting, such will be used concurrently with and not in displacement of the older

form. At present Kilakarai and its vicinity possesses a larger fleet of sailing boats than any other port on the East Coast of the Presidency.

24. *Tuticorin.*—The excellence of this port as a haven for small craft is too well known to require description. It is enough to state that there is good anchorage and shelter within the harbour for any number of boats drawing up to 6 feet. Unfortunately the depth of water is decreasing steadily in most parts in consequence of a process of silting which is going on uninterruptedly and which is likely to convert Tuticorin harbour eventually into salt flats similar to those to be seen around Punnaikayal at the mouth of the Tambraparni.

From Tuticorin southwards to Manapad is the homeland of the Paravars, a shore-dwelling people who make the best sailors to be found within the bounds of the Madras Presidency; they are the traditional divers and boatmen of the Pescaria coast, the men whose ancestors worked the pearl fisheries for Pandiyan kings, for the Portuguese Crown, and for the Dutch East India Company, and who to-day contribute the finest and largest pearling boats to both the Ceylon and Tinnevelly pearl fisheries. So, while their sea-skill in handing sailing craft in the main has been learned in the hard school of experience, natural aptitude for the work is in their blood, innate and transmitted from a line of boat-sailing forefathers who have pursued the same calling through fully 2,000 years.

25. The roadstead where steamers calling at Tuticorin must anchor is from five to six miles from the landing and shipping jetties and without protection from the heavy seas and boisterous winds of both monsoons; the cargo to be handled is of great bulk, next in total tonnage after that of Madras, and it must be landed or shipped without delay whatever be the state of the weather. These considerations have caused the evolution of the finest type of open lighter on the coasts of India, boats running from 15 to as much as 60 tons register. They are massively built of 3 inch teak, stoutly ribbed, and lined with thick planking. Forward is a small space decked in for convenience in heaving anchor, and being boarded off serves as a store and occasional sleeping-place.

In build they bear a family resemblance to the fishing luggers of the British and French coasts. The stem is straight, the stern sharp, and the sternpost little raked. Their rig is a single lateen sail of noble proportions carried on a very stout mast stepped well forward. Unlike the pattamars of the West Coast the mast has a very slight rake and what it has is aft. A stronger and shorter mast can therefore be used and stepped

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well forward owing to the straight cut of the stem and deep forefoot. The latter characteristics enable these boats to beat against the wind in a way unknown to the pattamar and similar craft on the West Coast. No finer sight can be seen off our coasts than a fleet of these boats beating out to the roadstead in the face of a strong breeze. Heeling well over under the power of the great lateen that billows in graceful curve below its huge yard, these boats ride the seas in a manner that bespeaks the weatherliness of their model, and the skill of the helmsman.

For deep-sea fishing their beam is somewhat low; the absence of a mizzen would be a drawback in drift net fishing but with these points remedied and a full or halfdeck provided, I believe such a boat, manned as it would be by men accustomed to the rig from boyhood, would be perhaps as serviceable, seaworthy and speedy a fishing boat as one could desire.

26. This type of boat has never been employed locally in sea-fishing other than pearling, indeed owing to the great demand for lightermen at Tuticorin and the good wages paid, there is comparatively little fishing done at Tuticorin and what is done is largely carried on in canoes. The men are, however, quite willing to go with the times once it be shown that it is profitable to change their methods. Partly by reason of the increasing demand for good fish and partly to greater intercourse with Ceylon, the Sinhalese outrigger-canoe or *Kulla* is gaining a footing in Tuticorin. Four years ago the first one to be owned by a Tamil was brought from Ceylon; to-day the same owner possesses two and two others own one each, all employed in whiffing for seer (*Cybium*). These swift sailing boats in the season go long distances seawards, 10, 12 and even 20 miles from land. They are probably the first outriggers worked by Tamils, and few as their number still is, they, in common with the utilization of sailing lighters in the pursuit of flying-fish off Negapatam, indicate that the fisher community is awakening to the need for better sea boats in face of the larger demand for fish brought about by increase of spending power among all classes and the improvement in means of transit provided by the extension of steam communication.

In passing it is interesting to note that the demand for fresh fish in the Tuticorin bazaar has created the beginnings of a fish carrier trade; it is now a regular practice to despatch swift canoes from Tuticorin to the fleets of catamarans and canoes fishing off Vaipar northwards and off Punnaikayal to the southward to purchase fish as it is caught and hasten back with it to Tuticorin.

III.—The Boat-Catamaran Coast; Punnaikayal to Cape Comorin.

27. Along the stretch of coast between Tuticorin and Cape Comorin another change in the physical character of the shore line occurs; here no chain of islands lie parallel with the coast; in their place we meet with a number of fairly bold headlands stretching towards the east and north-east, usually continued a considerable distance in the latter direction by submerged reefs on which the surf breaks heavily in rough weather. These headlands provide good shelter for small craft on the northern side during the south-west monsoon, while from the trend of the coast and the reefs to seaward a fair amount of protection is also given during the remainder of the year. Away from the shelter of the land, the sea is frequently a stormy one, wilder indeed than the Madras sea for here the full force of the south-west monsoon is felt, intensified by the swirl of wind and current induced by the projection of Cape Comorin into the Indian Ocean. In consonance with this requirement to encounter and ride over the mountainous seas often experienced the catamaran has been perforce retained. At the same time owing to the shelter given by headlands, the ease with which boats may be beached without having to run the gauntlet of the cruel surf met with on the coast of the Bay of Bengal enables the form of the catamaran to be so modified as to become a better carrier and fit to carry larger nets and bigger catches. The boat-catamaran is the result.

This is a large form of catamaran composed of three logs semi-permanently secured together by cross pieces at either end in such manner that the side logs rise higher than the upper surface of the centre one so as to form a longitudinal hollow which entitles these craft to be termed boat-catamarans; they are enabled by this contrivance to carry and operate larger nets than their brethren further north who use the catamaran properly so called.

In consequence of the greater carrying capacity of these boat-catamarans the fishermen of the coast from Punnaikayal to Comorin use a form of net called the Maddai valai similar in construction to the Odam vala of the Malabar coast. It is a form of seine possessed of a distinct family resemblance with the tuck seine; like the latter it is a most effective engine for the capture of shoaling fish more particularly the sardine and mackerel. Besides the catamaran, dug-out canoes are much in evidence on this coast; they are used when fine weather prevails. They are employed chiefly in drift netting and line fishing; the Maddai valai or Odam vala appears not to be used

from these canoes, its use being restricted to the catamarans The latter as well as the canoes use sails in going to and from the fishing grounds, but in the case of the catamarans using the Maddai valai, which necessitates the co-operation of two boats, it is customary for one only to carry mast and sail, the second lashing alongside the first, one sail doing for the pair, a neat contrivance to economise space and give more room for nets and fish.

The principal havens on this section of our coast are as follows, taken from north to south :—Punnaikayal, Kayalpattanam, Virapandiyanpattanam and Trichendur, Kulasekarapattanam and Manapad, Periya and Sinna Thalai, Ovari and Kumari or Cape Comorin.

28. *Punnaikayal* or Pinnacoil as the orthography is usually corrupted has proud memories of the past. It was for long the principal settlement of the Portuguese on the fishery coast, being the centre of the pearl fishery administration in their earlier days. It was one of the many scenes of Saint Francis Xavier's activities; his eloquence and energy here rendered stable and permanent the adhesion of the Paravars to the Roman Catholic faith given a few years before for political reasons. Here too was reared the finest cathedral church ever erected on this coast, the fragment which exists attesting proportions nobler, and design more elegant than any church now existing locally. The town is of comparatively recent origin ; it did not exist at the time of Marco Polo's visit to this coast (A.D. 1292). Then Kayal, the Palaikayal of to-day, was the centre of the pearl trade and stood at one of the mouths of the Tambraparni. To-day it is several miles inland, separated from the sea by long stretches of low deltaic land intersected by winding creeks. Prior to the advent of the Portuguese the silting up of Kayal harbour had progressed so far that new settlements were made on the actual coast line, one at what is now known as Kayalpatnam, by the Muhammadan traders, the other by the Paravars at Punnaikayal, at the mouth of a branch of the Tambraparni. The Muhammadan choice was the better, for while both places have suffered by the steady accretion of sand on the seaward side, cargo boats of 30 and 40 tons are still able to ship cargo from the beach at Kayalpatnam, whereas Punnaikayal is now about a mile and a half distant from the creek entrance into which no boats larger than a canoe can enter.

At present Punnaikayal is an extremely dirty and poor-looking village set round about four whitewashed Roman Catholic churches in the middle of a waste of unreclaimed

alluvial flats. The land is but little elevated above sea level, so that in the flood time of the Tambraparni, water washes through the streets of the village lapping the base of the kitchen middens on which the huts are built, and converts the village temporarily into several small islands. That fever follows in the wake of the floods is of course natural. A good many of the people migrate to Tuticorin and even Colombo, finding work as boatmen—the Colombo pilot boats are largely manned by Paravars from this coast—and it is a movement that should be fostered. The principal reason for adhering to such an unsatisfactory situation is largely explained by the fact that a particularly rich fishing ground exists opposite the village in the form of a deep depression or basin in the sea floor extending eastwards for 3 miles from about $1\frac{1}{2}$ mile from shore and averaging 1 mile in breadth. The bottom is fine sand and mud and varies in depth from 7 fathoms on the west side to 18 and 20 fathoms at the extreme east, where it shoals suddenly to $7\frac{1}{2}$ and 9 fathoms rocky bottom. Over the area of this curious depression the Punnaikayal fishing fleet works during the greater part of the year seldom having to go further afield for their harvest.

29. *Kayalpatnam.*—This harbour is very small but such as it is, it gives good and convenient shelter in any except a dead north-east wind. Deep water, 9 to 12 feet, is found close to the beach; there is usually no surf and boats of 30 and 40 tons can moor head to beach near enough to permit of cargo being carried aboard by coolies. Constant traffic with Tuticorin is maintained the whole year round by means of Tuticorin lighters, the chief item of shipment being salt from a factory on one of the creeks of the Tambraparni. The harbour is formed by the projection of a small rocky ridge overlain with sand at the south extremity, which, with Trichendur Point, gives protection from the south-west and south. From the end of the south horn of the little bay a submerged reef is continued towards the north-east and breaks the force of the sea from south round to east-by-south. To the northward the land trends a little to the eastward of north, but very slightly, hence a north-east wind blows right into the bay. With a stout stern mooring out, native craft do not suffer as the holding ground is good.

Scarcely any fishing is done here, the Lubbais of the place being largely engaged in trade or employment in other towns, more especially as boatmen, boat owners and pearl merchants, often returning to Kayalpatnam to spend the evening of their days.

30. *Trichendur and Virapandiyanpattanam.*—At the extreme south of Trichendur bay, is the little village of the same name, while further north and more in the bight of the bay is the landing place for the large town of Virapandiyanpattanam. The latter is the handier port to reach and was selected in 1900 as the pearl fishery port of that year. The bay is a repetition in physical character but on a much larger scale of the Kayalpattanam harbour; the lofty headland of Trichendur shelters from the south, while Trichendur reef stretching 3 miles to the north-east affords good shelter, except to the north-east, to the anchorage of Virapandiyanpattanam, situated $2\frac{1}{4}$ miles west-south-west from the northern extremity of the reef through which are many passages well known to local fishers and boatmen. Fishing boats using this harbour would probably find it advisable during the worst of the north-east monsoon to use the anchorage off the village of Alanturai which lies to the south-west of Trichendur Point. Little fishing is at present carried on from Trichendur bay.

31. *Manapad and Kulasekarapattanam.*—These two ports are the counterparts of the two just described, Manapad being a Paravar fishing town built under the shadow of the lighthouse-crowned promontory of Manapad, while Kulasekarapattanam is a cargo port $1\frac{1}{2}$ miles northward to which small native coasters resort.

Manapad point, which is 8 miles south of Trichendur pagoda, is a high rocky headland jutting boldly into the sea with a submerged reef extending from 3 to 4 miles to the north-east of the point and another for about 1 mile to the south-east. North of the headland there is a great extent of foul ground over which are heavy breakers in the north-east monsoon. Westward of this broken water lies the Kulasekarapattanam anchorage, reached either through the wide passage south of Trichendur point or through one or other of many small channels leading through the breakers. During the prevalence of east and north-east winds this anchorage is insecure and subject to a heavy breaking swell. At such times boats using Manapad or Kulasekarapattanam might find it advisable to land their catches at Periyathalai, a large fishing village five miles south-west of Manapad.

Manapad is a thriving well-kept town possessing a large fleet of boat-catamarans and a fair number of canoes. When I visited it on 14th October, the catamarans were landing large catches of sardines. As a fishing centre it has the advantage of cheap salt, a large factory being situated about $1\frac{1}{2}$ miles from the outskirts.

32. *Periyathalai, Sinnathalai, Utankudi and Ovari.*—These are busy fishing villages situated in shallow indentations in the coast line south-west of Manapad. As the coast here runs south-west and north-east, there is good shelter during the north-east monsoon, but during June, July and August the heavy sea and swell which roll in from the south precludes the possibility of deep-sea boats lying off these villages. At such time they would have to seek shelter at Kulasekarapattanam or Virapandiyanpattanam.

33. *Kumari* is a pretty and well-built town under the lee of Cape Comorin. Many catamarans and canoes use it as their port, and in the north-east monsoon the shelter it affords is excellent.

During the months when the south-west monsoon is strong it has the same disadvantages as Ovari and Periyathalai and during that season deep-sea fishing boats would either have to be hauled up or sent to a more favoured port. Probably the most profitable arrangement during the south-west monsoon for large boats hailing from the open ports from Manapad southwards would be for them to shift their working base to a northern port, Negapatam or Madras for preference.

IV.—The Canoe or Malabar Coast.

34. Taking Malabar in its wider sense to include both the districts of Malabar and South Canara, we find complete uniformity in the type of locally owned fishing boats employed along the whole coast from Cochin to Mangalore. Except at Mangalore and to the northward where large fishing boats from Ratnagiri are to be seen, the dug-out is the only fishing craft in use, even catamarans are absent. Two models only are used, the one flat-bottomed, the other somewhat rounded below. The chief differences lie in the size and the purpose for which employed. The larger, which run to 32 feet in length by 3 feet wide and $2\frac{1}{2}$ feet deep, and of 3 to 5 tons burden, are usually used in pairs, chiefly in working the net variously called odam, peru or nallu-vala in Malabar and maribalai in South Canara; the smaller, averaging about two tons burden, are employed principally by the long liners (beppu) or the casting-net fishermen. The larger boats usually carry seven of a crew, the smaller three when lining, four when used in cast-net fishing.

Such uniformity in type of boat along the whole of this coast bespeaks uniformity in physical conditions and in fishing methods, an inference which on examination proves to be

PLATE II.

MADRAS FISHING BOATS.

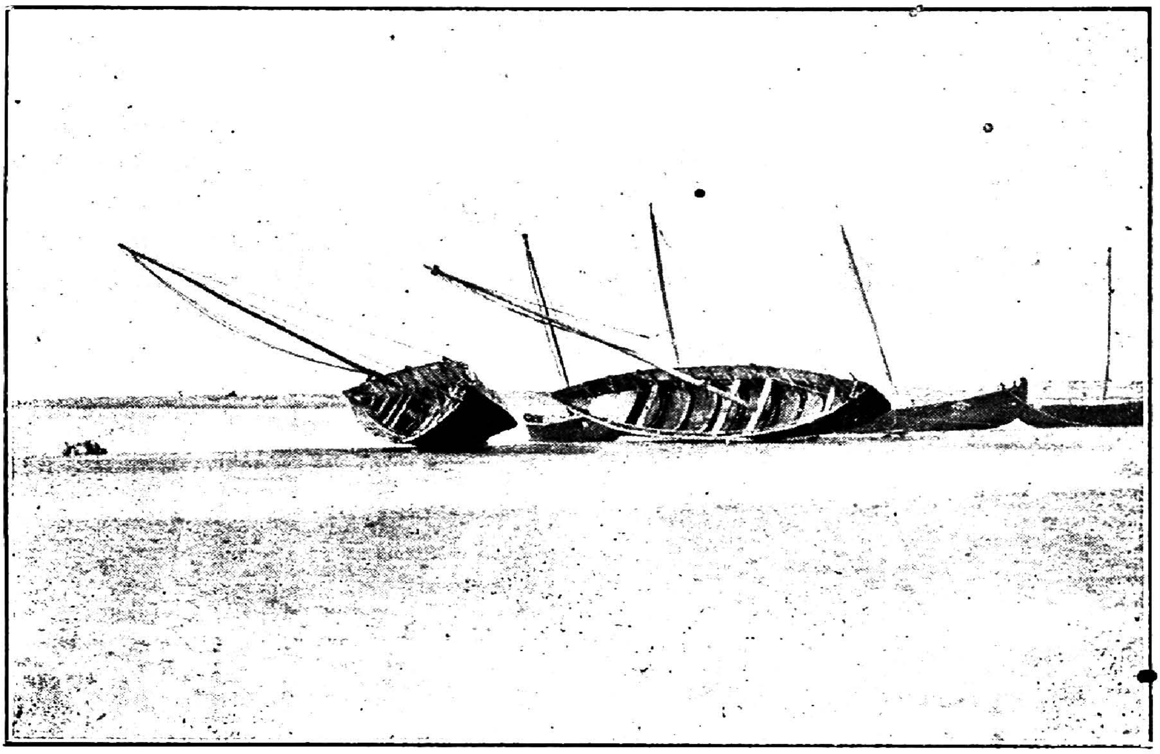

FIG. 3. TUTICORIN CHANK-FISHING CANOE-BOATS.

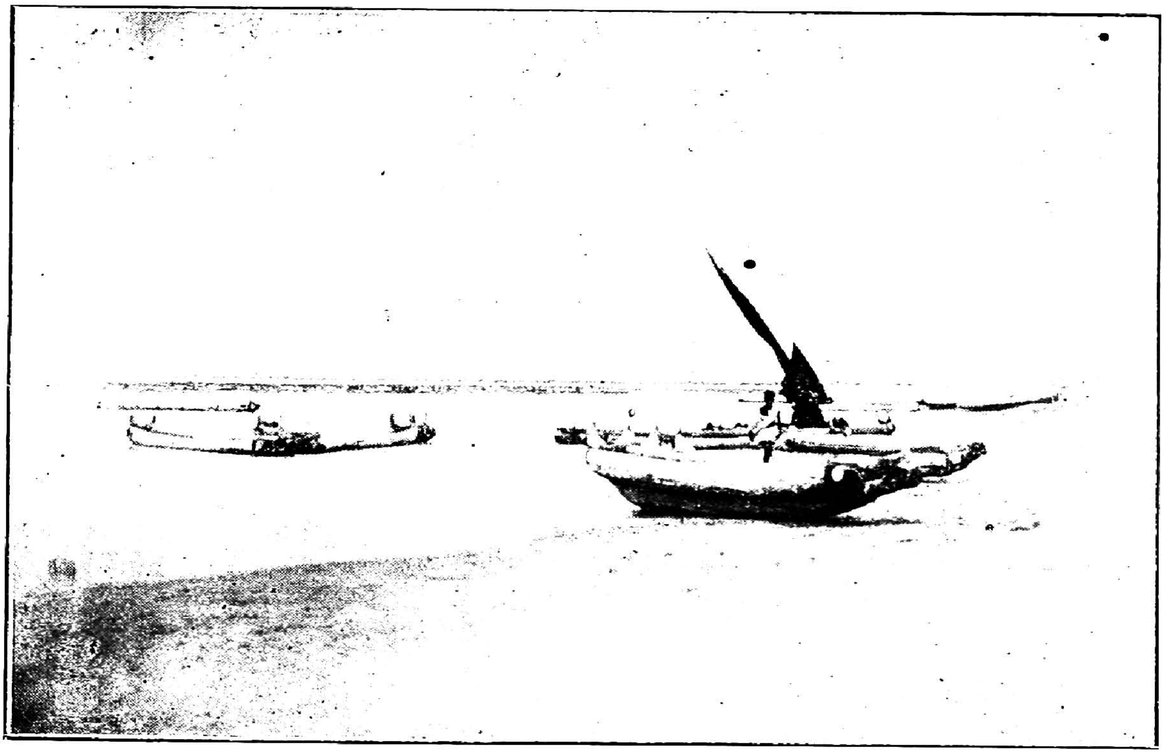

FIG. 4. BOAT-CATAMARANS IN PUNNAIKAYAL HARBOUR.

[*Photo. J. Hornell.*]

PLATE III.

MADRAS FISHING BOATS.

FIG. 5. A GROUP OF MADDAI VALAI NETS DRYING, PUNNAIKAYAL.

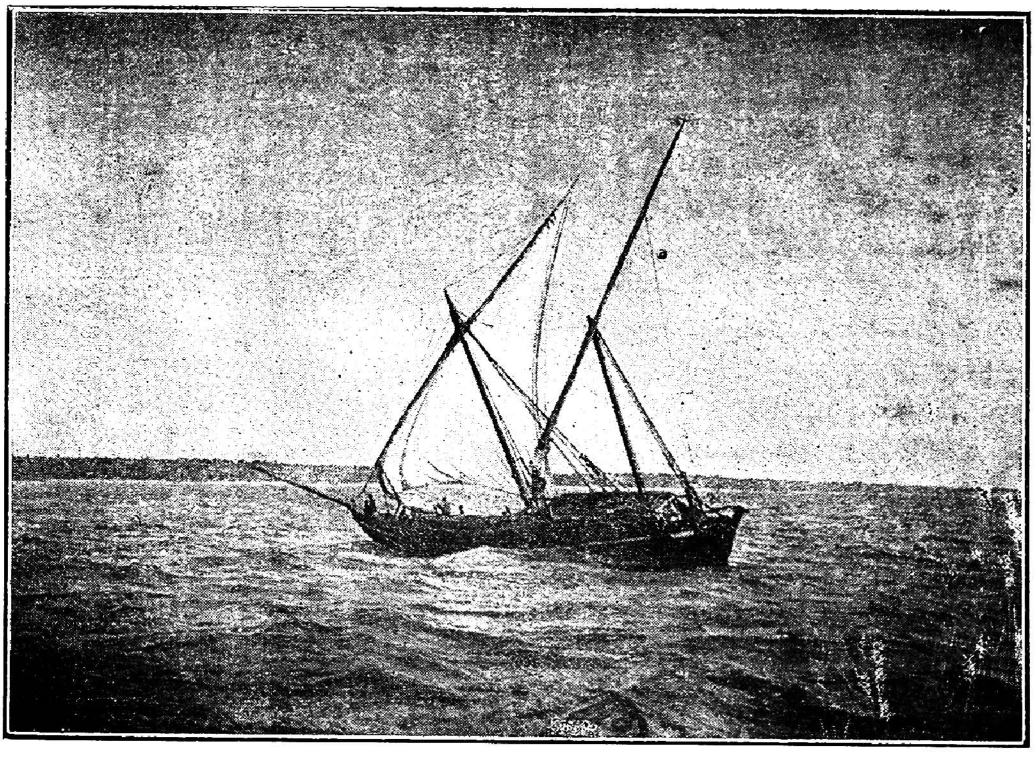

FIG. 6. A MALABAR COASTER MAKING FOR COCHIN HARBOUR.

[Photo. J. Hornell.]

correct. Along the whole coast fine weather prevails during the north-east monsoon, not relatively fine weather as we get inshore on the East Coast during the south-west monsoon, but actual "summer seas" with gentle land and sea breezes which carry the boats to the fishing grounds in the morning and bring them home in the afternoon at the most convenient of hours. More than this, the majority of the better fish found on this coast also study the convenience of the fishermen by coming close inshore in most years and coming not singly or in small groups, but in huge phalanxes or shoals. Nature calls for no special effort to be put forth on the part of the Malabar fishermen so far as inshore fishing is concerned, hence the dug-out being found sufficient has not been improved upon.

The canoe in this part of India has no lesson for us save to indicate how well sheltered the whole Malabar coast is during half the year; for this period the whole extent of the coast is one continuous haven, when the principal value of having a number of ports or specific landing places is that such may be chosen at or near centres of population or convenient to railway stations whence some part of the catches may be despatched inland in a fresh condition. During the other half of the year the conditions are very different; a heavy sea rolls in upon the shore and precludes the possibility of small vessels anchoring near the land in safety except at a few exceptional places favoured by the presence of phenomenal mudbanks. From 15th May to 15th September the river ports along this coast are virtually if not actually closed, many of the buoys are removed and some harbour lights temporarily extinguished. Under such unfavourable conditions, even though there be occasional lulls in the violence of the monsoon winds, it would be, I fear, hardly worth the risk for large fishing boats to remain in commission on this coast during the south-west monsoon. They should, however, be able to resume operations towards the middle or end of August, especially if they utilise the advantages of the mudbanks off Alleppi, Narrakal (Cochin), Calicut and Quilandi; St. Mary's Isles and Mount Dilli at this season also offer good shelter from strong north-west winds which occasionally prevail. To men with ample local knowledge the many river mouths along this coast would also be serviceable at this period as harbours of refuge in and out of which they could work, as do cargo boats at present at several ports, according to the promise of the weather.

Alternatively to this laying up for several months, large fishing boats employed on this coast during the north-east monsoon might sail round to the Madras side for the south-west

monsoon season, making Negapatam, Porto Novo or Madras their base as might be found most suitable.

35. The general character of West Coast ports may be summed up in the statement that from October to May small vessels may anchor close inshore at almost every one and that light-draft craft built on the lines of the proposed fishing boats may cross the bars of the principal river havens for some time before and after high water. Naturally some ports offer greater advantages than others; for the sake of reference I shall now give a brief note upon the respective advantages of those most likely to prove useful havens if sea-going fishing boats come to be employed in numbers.

Under present conditions Cochin, Mangalore, and Calicut (with Beypore) enjoy a decided superiority over all others, the two first because their river havens may be entered at any state of tide, the last because of the presence of an extensive mudbank, which for three years past has provided a smooth water inshore anchorage along the sea front and given surf-free landing for a considerable distance south of the port pier.

Of ports less highly favoured, but perfectly suitable for the purpose in view, quite a number are available, namely, Quilandi, Malpi, Kundapur, Beliapatam and Mount Dilli together, Tellicherry, Ponnáni, Cannanore, Chaughat and Mahé: the names as arranged indicate approximately the order in which they appear to rank as fishing-boat centres considered from the point of view of safety. Between the first five there is very little to choose, all are most excellent, each in its own way; the last named four are also safe havens from October to May.

36. To give a few of the more important particulars ascertained during a recent tour along the coast regarding each of these havens—

Cochin is the best river harbour in the whole Presidency for the six months during which the north-east monsoon prevails; during the rest of the year the port is considered unsafe and is closed to sailing vessels from 15th May to 15th September between which dates the bar buoys are removed. During this season boats may anchor in safety in smooth water on the mudbank about two miles north of Cochin bar. Formerly this bank lay off Narrakal, a small place five miles north of Cochin; of late years it has shifted gradually southwards till now it lies off Mallipuram, two miles to the south of Narrakal. At the first burst of the monsoon considerable sea is usual on this mudbank and on the beach eastward, but at the end of about a week so great a quantity of excessively fine mud passes into suspension in the water that the same effect is produced as oil

would have, the sea becoming perfectly smooth and of a lake-like stillness although beyond the limit of the bank high seas may continue to run. The beach consists of very soft mud and affords smooth landing during the south-west monsoon.

The Cochin bar at present has about 11 feet of water in the shallowest place at low water of spring tides, springs rising 3 feet. A 2,000-ton steamer has entered, light, and come out safely on 13 feet partly loaded. Depths of 6 to 7 fathoms are found immediately within the entrance channel together with a very large area of suitable anchorage available for boats drawing 8 feet and under. A strong current sets out during the ebb and renders the bar dangerous to small boats when opposed by a sea breeze.

Apart from its great natural advantages Cochin is at present particularly well situated to become a great fishing port; it is within easy reach by rail of Coimbatore, the Nilgiris, and a great inland district where the people at present never see fresh sea fish; the port has long had a great and well deserved reputation for the excellence and reasonable prices of the ships turned out by its shipwrights—an industry favoured by the neighbourhood of the Cochin forests; finally Cochin now possesses an extensive fish-manure and fish-oil factory built by one of the foremost British fish manure firms and equipped with the most modern machinery adapted to the economical and rapid treatment of the raw materials employed.

37. *Chaughat*, 36 miles north of Cochin, is the most southern port in the Malabar district, for though Cochin is within this Collectorate for administrative purposes, its geographical position links it with Cochin State and Travancore. There is good mud anchorage off the river mouth, and small craft are able to enter the river at high water. It is doubtful whether fishing boats drawing 3 feet of water would be able to use this river as a port of refuge; in bad weather they would probably have to run for Ponnáni, 18 miles to the north or bear down southwards for the Narrakal mudbank. Fishing is extensively carried on at this port at present by canoes; a large proportion of the fish is salted, consumption in the fresh condition being very restricted.

38. *Ponnáni*, 18 miles north of Chaughat, is situated at the mouth of the Ponnáni river. Its physical situation is practically the same as Chaughat with the important difference that there is considerably greater depth of water on its bar. Usually boats drawing 5 feet are able to enter even at low water, there being in normal seasons 6 feet water at low tide of ordinary springs, with 4 feet rise to high water. It is a busy

port with a large trade in timber, tiles and cured fish. A number of large cargo lighters belong to the port; several boats from 20 to 40 tons were under construction on the day of our visit.

39. *Tanur*, a large town and a place of considerable fishing importance, affords no shelter to boats, which have to anchor in the open roadstead abreast of the town.

40. *Calicut and Beypore* may be considered together, Beypore being only 6 miles to the south of Calicut.

Some three years ago the mudbank which then lay off Varakal, a small village about 3 miles north of Calicut, moved down the coast till abreast of the commercial quarter of Calicut and has remained there since, rendering this port one of the most convenient upon the coast. The population is large and comparatively prosperous, making it a good centre for the local sale of fresh fish; ice too is procurable from a small factory able at present to turn out 2 tons per day, so were a regular supply of good fish to be available, such as sea-going luggers would provide, a good opening is present for an enterprising firm to organize a profitable inland iced-fish trade. The outlet for well-cured fish is also excellent, as Colombo-bound coasting steamers call regularly at frequent intervals.

Beypore river gives excellent accommodation for laying-up purposes; the least water on the bar is 4 feet low water spring tides, while the rise to high water springs is 5 feet, of neaps 4 feet; the range of neaps is 2 feet. Within the river there is ample anchorage, good bottom from 9 to 17 feet, low water springs.

Both at Calicut and Beypore buggalows and large pattamars may always be seen on the stocks; the shipwrights here are fully capable to build to European designs; in November this year, three large Arab buggalows were hove down on the open beach near Calicut old lighthouse for repair and general overhaul —a fact which speaks well for the excellent protection afforded by the mudbank.

41. *Varakal* was formerly the landing and shipping place for Calicut cargo in rough weather, prior to the shifting down of the Varakal mudbank to Calicut, three years ago. It is quite probable that the bank will move back to its old position one of these years in which event Varakal would become a suitable fishing boat haven.

42. *Quilandi* is a place of considerable size, 12 miles north of Calicut. A mudbank similar to that at Calicut lies abreast of the town giving excellent anchorage and an easy landing free from surf. The coast to the north forms a shallow bay

bounded on the north-west by Kadalur Point, affording shelter from the north-west winds which frequently blow with violence from February to May. Sacrifice rock, the centre of a noted fishing ground in this district, lies 10 miles west-north-west.

43. *Badagara*, an important fishing and trade centre 12 miles north of Quilandi, offers no special shelter to sailing craft; the anchorage is an open roadstead, good mud holding ground. In stormy weather boats might run either for Quilandi or for Tellicherry, 10 miles northward.

44. *Mahé river*, 7 miles north of Badagara, has a narrow entrance much impeded by rocks; the bar is considered dangerous except in fine weather; at high water vessels drawing 5 and even 6 feet are able to pass in. Several buggalows were at anchor within the river in November 1908. The port is closed during the south-west monsoon.

45. *Tellicherry*, 4 miles north-west of Mahé, already a very busy fishing centre, offers good shelter to small craft in the fine season, the inshore anchorage rendered smooth by the presence of a small mud-bank and with additional protection from north-west winds by a natural breakwater of rocky reefs and islets stretching south-west from the northern extremity of the port. One of the busiest and best conducted fish-curing yards in Malabar is situated here, enormous quantities of sardines, mackerel, catfish and sharks being cured, largely for export to Ceylon by the coasting steamers of the British India and Asiatic Steam Navigation Companies. A mile and a half north-west of the port, the mouth of the Anjerkandi river offers facilities for small craft to lay up in bad weather or for repairs. It is regularly so used by the cargo lighters serving this port.

46. *Cannanore.*—Good anchorage for small vessels is found close inshore in the bight of the bay south of the fort and military ground. It has the advantage of being sheltered from the north-west as well as the north and north-east directions; landing is usually easy; a long swell is very characteristic of this anchorage in certain seasons, especially if there be westerly or southerly winds; in November 1908 we experienced this most markedly on the two occasions we were anchored there in the S.S. "Margarita"; in both instances the swell was considerably greater and more pronounced within the bay than outside and it continued for hours after the land breeze began with the consequence that laying to the wind we were almost broadside to the swell, rolling abominably. The port is practically closed from the beginning of June to the end of August, being fully open to the south-west.

47. *Mount Dilli and Beliapatam river.*—Mount Dilli, the boldest headland on this coast, lies 12 miles north of Cannanore. It forms a conspicuous landmark, visible from a distance of 25 miles in clear weather, but "in the hazy weather of March to April scarcely 15 miles." In the bay to the south-east small vessels find convenient shelter during the north-east monsoon, especially against north-west winds which frequently prevail off this cape from February until May, and which are accompanied by a short confused sea.

The Beliapatam river enters the sea midway between Cannanore and Mount Dilli. It is an important inland waterway navigable for large boats the whole year round for some distance from the sea. In conjunction with the bay under the lee of Mount Dilli this river port would form a useful fishing and distributing centre. Indeed it has already been so used, as some Ratnagiri boats which until a few years ago were brought down the coast by a Cannanore fish contractor made this place their base. The anchorage is not so cramped as at Cannanore, there is less swell and the river mouth is handy in the event of rough weather coming on.

Mount Dilli may be said to mark the northern limit of Malabar, and the southern of South Canara.

48. *South Canara.*—The 52-miles stretch of coast line between Mount Dilli and Mangalore is uniformly low and sandy with no headlands to give shelter and intersected by but few rivers and those in all cases so shallow as to be available only for small boats. Of these rivers Kavai immediately north of Mount Dilli is the best; Kassergod river estuary and Cumla creek are the only others of importance and in both cases the position of the bar and the depth of the water over it, are so variable that it would be misleading to give any figures. This is of little importance however in view of the proximity of the first-class port of Mangalore.

49. *Mangalore*, the chief town of the South Canara district, possesses a river port having at present not less than 9 feet of water at low water of spring tides on its bar; ordinary springs rise 7 feet, neaps 5 feet. In November 1908 the S.S. "Margarita" drawing 7 feet 8 inches had no difficulty in entering and leaving at any state of the tide except that in leaving at low tide, turning room was at times greatly restricted by the awkward anchorage taken up by several native craft. The anchorage opposite the lighthouse carries from 10 to 14 feet at low water springs and there is a large area available with soundings from 4 to 6 feet at the same state of the tide, suitable for fishing boats.

This port is a favourite with the Ratnagiri and Rajapur fishermen, who bring their boats here regularly under contract with the local fish merchants, staying from October till March. The boats they use are of three sizes, but all are intended for deep sea drift netting. From October to the end of December, the two smaller sizes are employed, leaving harbour usually at 2 to 3 P.M. and returning the next day between 10 A.M. and noon. The drift net used at this season is the vowri-balai, having a mesh of $4\frac{1}{4}$ inches and made in pieces measuring 20 to 27 fathoms each. Usually 40 of these pieces are attached together to form a fleet of nets. Principally bonito, small seer and shark are taken in these nets.

About the end of the year the smaller Ratnagiri boats return home being replaced early in January by larger boats with big-meshed drift nets used in deep water almost exclusively for large sharks and rays. These Ratnagiri boats are excellently built, very broad in the beam, handsome in the lines, and carry a great press of sail. As our home boats do, these also lower the mast—they carry but one—upon a crutch when riding to their nets. The shark drifters usually stay out about three days; occasionally as long as seven. In the latter instances their catches are landed in very bad condition, often crawling with maggots, the quantity of salt taken to sea being inadequate to preserve the fish satisfactorily. The large boats are said to cease work about the end of March or beginning of April.

The two larger boat types used by these men from the north are lateen rigged and are true boats, reminding one much of the general design of Danish and Nordland open fishing boats. In both there is the curved and overhanging stem, the sharp stern and raked stern post; both are low in the waist, and with comparatively low freeboard, in both a wash-strake is fitted when heavily laden, and both depend on a single mast and single sail.

The smallest of the three Ratnagiri types in some respects is the most interesting as it is, I believe, the highest development of outrigged canoe. The basis, in common with the Ceylon form, is a dug-out canoe, but on this has been raised not perpendicular sides less than 18 inches apart as in the Sinhalese model, but a series of strakes flaring outwards considerably and producing a fairly roomy boat capable of carrying a fleet of nets about half the length of that used by the smaller of the two larger boats. The outrigger is boomed out in the usual manner, and the boat carries a sail of the same type as her larger sisters.

50. *Mulki*, a fishing centre about 12 miles north of Mangalore. The river entrance dries nearly across at low water springs, but has 6 to 7 feet on the bar at high water.

51. *Malpi and St. Mary's Isles.*—Malpe is a flourishing fishing centre at the mouth of the Malpe river, well protected to the westward by the chain of St. Mary's Isles, three in number. The channel between these islands and the mainland is about a quarter of a mile wide with depths of 6 to 12 feet at low water. During north-west winds, small sailing boats find shelter under the lee of Deria Bahadur Ghur, the middle and highest of the islands. The Malpe fish-curing yard when first opened was located on the island named; later it was transferred to Malpe. The Ratnagiri boats working from here do not usually enter the river; they land their catches on the beach abreast of the village and when they lay up for a day to clean up and oil their boat and nets, they move over into the lee of Deria Bahadur Ghur. Malpe river offers good shelter also, the bar although shallow being so well protected that the sea does not usually break thereon. We crossed it several times at the end of November, finding the least depth to be 4 feet. At low water ordinary springs there are sometimes places with but 2 feet water, but as springs rise 8 feet and neaps 6 feet, there is ample water at certain states of the tide for pattamars and batelas to enter. Quite a number were within the river at the time of our visit.

52. A very large shore seine called the Rampini or Rampan net was introduced here from Goa some years ago. At the present time there are quite six of these nets in use here each owned co-operatively by as many as 45 shareholders, who contribute both in labour and in material. A large outrigger boat is used to load this huge net said to measure over a mile in length. The condition of the fishermen appears to be good; the introduction of this Rampini net admittedly has done much to improve it, for though the cost of a net is comparatively high, Rs. 1,500 to Rs. 2,000, huge catches are made when shoals appear in the bay. One net which we saw hauled ashore produced 4 tons of sardines alone, and we heard of another haul the same day that yielded 10 tons. These were being dried on the beach for manure. Besides sardines, mackerel (*Scomber microlepidotus*) was being taken in large quantities at the same time; the fish-curing yard was full of them, and the Sub-Inspector informed us that close on 3,000 maunds (= 110 tons) had been brought to the yard the day previously, all caught by means of this Rampini net.

53. *Kundapur river*, 18 miles north of Malpé, is the last port in South Canara. It makes a good fishing station, as the river has a depth of 10 feet at high water of spring tides, with about 2 feet at low tide.

54. Table of the mean range of ordinary spring tides at ports in the Madras Presidency:

West Coast.

	Mean range in feet.
Malpé and St. Mary's Isles	8·0
Mangalore ...	7·0
Cannanore ...	4·5
Tellicherry ...	4·5
Calicut and Beypore	4·1
Chetlat and Kiltan (Laccadives) ...	7·0
Allepi	3·0
Quilon	2·8

East Coast.

	Mean range in feet.
Tuticorin ...	3·2
Pamban	2·6
Ammapatnam ...	1·25
Negapatam ...	2·6
Madras	3·5
Cocanada ...	5·0
Vizagapatam ...	5·1

V.—General Conclusions.

55. From a study of the details given above, several facts of outstanding importance emerge; we see that the differing conditions of weather and physical characteristics met with on different sections of the coast and sometimes even at ports on the same part of the coast have in the past necessitated the employment of fishing craft and cargo lighters of several different and distinct types to conform with special local requirements, a fact to which we must give full weight when deciding upon the design and rig of any experimental deep-sea fishing boat to be introduced at special ports; we see that although the West Coast of this Presidency, with an extent of coast line one-fourth of the extent of that on the East Coast, produces according to Sir F. A. Nicholson's computation thrice the weight of fish taken on the other, the fishing season there is restricted in large measure to the fine weather season of the north-east monsoon; lastly, *we have to note the success of deep-sea fishing wherever an attempt has been made to work it with large or specially designed boats*, by the fine Ratnagiri boats drift netting off the Canarese coast, the seer lining off Tuticorin, and the flying-fish fishery off Negapatam and Tranquebar; we have noted further that, with the exceptions named, the fishing craft of the Presidency are wholly unsuited by reason either of smallness and lack of shelter, combined in the case of the Malabar canoe with inability to face even moderately rough weather, to make prolonged trips to sea and to carry nets of

the large dimensions required to make deep-sea fishing a success. This last matter has already been dealt with very fully by Sir F. A. Nicholson in his several reports on the Madras Fisheries and may now, I think, be taken as granted.

56. *The selection of fishing centres and the necessity for separate classes of fishing ports.*—The catamaran having conquered the surf, special fishing ports or havens have not been requisite hitherto in the districts where this type of craft is in use; wherever a sandy beach is found the catamaran may be used, hence in the neighbourhood of populous centres the whole coast line for miles together is used indifferently by the catamaran men. On the East Coast where fishing is confined very largely to a fair weather season when landing is easy almost anywhere, the same result is seen; fishing hamlets dot the coast irrespective of any consideration for the superior shelter to be had within neighbouring river mouths, indeed the open beach has quite a superior attraction in the eyes of fishermen as its use enables them to reach the fishing grounds more quickly than if they had to come from out a river mouth.

57. The case of sea-going boats is wholly different. Of necessity they must be of such a build and depth as preclude them from being hauled up daily upon a beach, and, with the exception of the West Coast during the fine season, it would not be advisable to anchor them off the open beach (except at Point Calimere) unless there be a safe haven within easy reach in the event of a sudden outset of stormy weather. Even this would entail risk in many localities and would necessitate one or more of the crew remaining aboard at all times. We may expect therefore that if any considerable number of boats eventually take up work on our coasts, the same process of local centralization will take place here as has taken place in Britain as the village cobble gave place to the smack and the latter in turn to the steam trawler and steam drifter, till at the present day the fishing craft belonging to half a dozen ports monopolize between them three-fourths of the entire fish trade of England and Scotland.

58. Apart from the matter of safety, the selection of special fishing centres is desirable in fishing interests as only by so doing can outside capital be attracted and the industry placed on a sufficiently wide basis. Catamaran and canoe fishermen may be likened to retail traders; large fishing craft must be handled on broader lines and made to conform to commercial ideas of wholesale trading. To be profitable the catches of sea-going fishing boats must be large and they must

be landed at centres where there exist special facilities either for curing or for disposal in the fresh condition. For the former the proximity of a salt factory whence salt may be obtained without incurring heavy transit charges and of a conveniently situated fish-curing yard are the main desiderata; for the latter the most suitable centres will be such as will possess a large population, or offer special rail facilities for the transport of fish inland; the presence of an ice factory at any rail port will be an attraction of no mean weight.

59. In a survey of the East Coast from a point 100 miles north of Madras (I have not been able as yet to visit the maritime districts beyond the Penneru river) the most suitable centre whence a fleet of sea-going fishing boats may work is undoubtedly Madras. It fulfils every requisite condition—a harbour offering in the new boat basin absolute protection even against cyclones, a population aggregating over half a million, an excellent train service, and the largest ice factories in South India.

60. North of Palk Straits, Negapatam probably offers advantages which would rank it next after Madras, principally because the fishing grounds off Negapatam and Point Calimere and extending thence towards the north of Ceylon are particularly rich both in surface and in bottom fish and because the railway from Negapatam gives rapid access to the rich Tanjore and Trichinopoly districts, these towns being reached in 2½ and 4 hours respectively from Negapatam.

Cuddalore and Porto Novo are also promising centres; they are fairly good havens and both well served by the railway.

61. Boats fishing from the above-named ports presumably would dispose of the bulk of their catches in the fresh condition; for those relying more upon curing as an outlet for their catches, Tranquebar and Kistnapatam are the most likely ports, the special reason being that a salt factory is situated within a short distance from the landing place in each instance. Cheap transit by water is available at both ports, at Kistnapatam by means of the Buckingham canal, at Tranquebar by native coasters.

62. Of the numerous ports available south of Palk Straits, Tuticorin is probably the best favoured; its harbour is safe and open the whole year round, it is a rail terminus, is situated conveniently to a salt factory, possesses an enterprising population, keen traders, and the best of boatmen, and maintains steamer connection with all parts of the world.

Pamban, Kilakarai and one of the ports near Manapad rank next, their relative value to be gauged only after practical experience has been gained.

63. Rounding Cape Comorin to make a choice of fishing centres, we are confronted with the fact that excellent as are so many of the ports on the Malabar and Canarese coasts, the fishing season there is limited to the fair weather period from October to May inclusive. During the rest of the year the fishing fleet must either lay up or follow the good weather to the East Coast.

64. Apart from this consideration, the most suitable fishing centres arranged in the order of probable importance, due regard being given to the conveniences at present available for rapid and profitable disposal of the catches both in the fresh and cured conditions, are:—Calicut, Mangalore, Cochin, Tellicherry, Cannanore, Ponnáni and Malpe. The first four indeed appear practically on a par with one another, Calicut's special advantages being the location there of a small ice factory and the shorter railway journey thence inland. Apart from these advantages Mangalore has particular claims as it is already used as a deep-sea fishing centre by the Ratnagiri boats and has the largest dried fish export of any town on the west coast. Further, Mangalore is the nearest port to that immense ocean shoal, the Bassas de Pedro or Munyal Par which extends 70 miles from north to south and is 10 to 15 miles in breadth. Judging by analogous conditions the bottom, which consists of sand, shells and coral at a depth of 22 to 28 fathoms, appears particularly well suited to be the resort of very great quantities of valuable bottom fish. This great bank is virgin fishing ground as it lies a full 100 miles from the nearest land and cannot be exploited save by boats able not only to keep the sea for a fortnight but if need be to face severe weather with confidence.

The Sesostris bank, another promising ocean bank lying 15 miles westward of the Bassas de Pedro, also awaits the advent of large sea-going fishing boats working out of Mangalore harbour.

65. *Types of boats.*—The design of the sea-going fishing boats suitable to work from the various harbours enumerated above will be subject to considerable variation dependent upon (*a*) the particular fishery on which employed, lining, drift-netting or trawling, (*b*) upon the character of the harbour or coast where employed, and (*c*) lastly upon the length of the trips to be made and whether the catches are to be brought ashore fresh, alive or more or less partially cured.

66. Working out of deep water harbours, boats such as the latest designs of Scotch herring boats, are indicated as most suitable for lining and drift-netting; decked boats of this type should hold their own in any weather commonly encountered off Indian coasts and quite suitable to make the long journey from Mangalore to the ocean banks north of the Laccadives. Whether the local lateen sail, serviceable, simple, and immensely powerful, should be retained, or whether it may be replaced by the handier British lug and mizzen can only be decided by experience; it should be the aim of any working experiment in deep-sea fishing to settle this point by specific trial, either by working competitively two boats rigged in the two fashions or by trying one boat first under the one rig and then under the other, under the same conditions and for a period of several weeks at each trial. The big lateen has the initial advantage of being already thoroughly understood, excellently handled by the men of these coasts particularly by the boatmen of Tuticorin and Pamban and by the Bombay men who man the Ratnagiri fishing boats and the fleets of pattamar coasters seen in such numbers along the west coast during the north-east monsoon; as developed in the Tuticorin cargo boats this sail gives wonderful speed in the light winds so characteristic of our seas.

European boats, especially those of Great Britain and France, are built and rigged to withstand Atlantic gales, perhaps the worst weather to be met with anywhere in the world; and, as their fair weather winds are generally stronger than our ordinary winds, the sail area carried by a Scotch fishing lugger is very considerably less than Indian coasters of the same size habitually carry. For example in a design of a typical fishing lugger as used in British waters, the sail area works out at 900 square feet in a 40-foot boat, whereas an Indian designer gives 1,500 square feet sail area to a 50-foot boat.

67. No restriction as to depth and draft of water need be placed on fishing boats using the harbours of Madras, Mangalore, Cochin and Pamban. Those using most of the other harbours in the first instance and till we have further experience, should be restricted to a maximum of 5 feet draft when loaded. For harbours with specially shallow entrances and those such as Kistnapatam where considerable surf breaks on the bar, decked boats of an improved Ratnagiri type, shallow, of great beam (more than 1 in 3 of the length), and with both stem and stern well sheered, should prove the most suitable.

68. The next step will be to translate these deductions into practice and to learn from every-day working experience carried

on for several seasons, what the extent of deep-sea fishing actualities are and what the limitations. As the first step towards this I would recommend the building of two fishing luggers each of 15 tons register, one to be built and rigged to the design of a herring drifter already obtained from Messrs. John Tyrrell & Sons, Arklow, through the courtesy of the Rev. W. S. Green, C.B., Department of Agriculture and Fisheries, Ireland, the other to be built on the lines of a Tuticorin cargo boat, modified in certain particulars such as increasing the beam, giving either a full or a half deck, and the addition of a small mizzen as a help in steering and lying to the wind when riding to drift nets.

ENNORE,
31*st December* 1908.

REPORT

ON

THE RESULTS OF A FISHERY CRUISE ALONG THE MALABAR COAST AND TO THE LACCADIVE ISLANDS IN 1908,

BY

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[With 27 photographs and text-figures.]

A fishery investigation cruise in the Government steamer "Margarita" was arranged towards the end of 1908 by Sir F. A. Nicholson, Honorary Director of the Madras Fisheries, with a view to collect such reliable data, by direct enquiry and experiment upon fishery problems on the West Coast of this Presidency, as would determine the most suitable lines on which practical development and the more detailed investigation of important problems should be conducted. Among the principal questions with which this investigatory cruise was to deal and to endeavour to elucidate were the following, namely :—

(*a*) The suitability or otherwise of west coast fishing grounds for steam-trawling.

(*b*) To what extent and on what lines are the industries of drift-netting and long-lining capable of development and extension.

(*c*) The determining influences which control the migrations of sardinesand mackerel, entailing an inshore superabundance in some years, a more or less complete dearth in others.

(*d*) An enquiry into the vertical and horizontal distribution of the microscopical organisms (plankton) which constitute the food supply of the smaller food-fishes.

(*e*) Observations at sea upon the principal methods of fishing pursued on the Malabar and Canarese coasts, with a view to introduce improvements both in boats and equipment and to determine if any appliances elsewhere in use are suitable and appropriate for introduction.

(*f*) An enquiry as to what ports on the West Coast are most suitable to serve as fishery centres in the event of deep-sea fishing being developed.

(*g*) The present condition of fishing industries in the Laccadive Islands and the potentialities which exist for the development of the marine resources of these islands.

Besides these primary lines of enquiry whatever opportunities offered for investigation of the food and parasites of fishes, and of the general marine fauna of the districts visited, were to be availed of so far as time would permit.

2. The working period of the cruise extended from 24th October to 10th December 1908, a period of seven weeks. During this time the coast from Ponnáni in the south to Malpé in the north was fully examined, the neighbourhood of Cochin was also tested by the trawl, and eight days were devoted to a visit to four islands in the Laccadive Archipelago.

A summary of the principal observations made, with such practical deductions as appear pertinent to the improvement and development of fishing industries, will now be given under separate headings.

A.—The suitability or otherwise of West Coast fishing grounds for steam-trawling.

3. I had purposed to give a detailed account and analysis of every trawl-haul made, but on going over the great mass of detail in my note-books it seems preferable to confine attention to the facts of main fishery importance and to hold over records of rare fishes and the like to the more appropriate occasion of a purely faunistic report.

In all, fifty-two hauls were made varying from half an hour to three hours in duration ; the majority were daylight hauls, but a number were made at night ; the latter gave no better results than the former.

4. A small 15-foot beam-trawl was employed principally ; during the last fortnight of work a yacht's 42-foot otter-trawl was also used. It would have been preferable to have had larger gear in the case of the beam-trawl or heavier in the case of the otter ; unfortunately the steamer at our disposal is ill-adapted to this form of fishing and without a costly refit, it was impossible to employ apparatus of greater power.

5. The evidence furnished by the investigation as a whole is most distinctly adverse to any prospect of the development of West Coast fisheries by means of steam-trawling within the 30-fathom line, a conclusion I was prepared for from a careful study of the charts of the area to be examined. With a few unimportant exceptions the bottom from about a mile from shore out to 30 fathoms, from Ponnáni northwards to

Mangalore, is composed of a soft dark grey mud with small dead shells, chiefly bivalves, more or less sparsely distributed through it. As a rule the sedentary fauna of this area outside of the 10-fathom line is extremely scanty consisting principally of small lamellibranchs (*Tellina*, *Arca*, etc.), some *Dentalium* and small gastropods with occasional hauls of large and beautiful *Rostellaria* and *Turritella*. Apart from these the fauna is sparse and inconspicuous, while algæ are of course entirely absent; to describe the bottom in the parlance of the dredgerman, there is "no feed on the ground," that is to say, such a poverty of life exists on the bottom that there is little attraction there for bottom-feeding fishes. These adverse conditions and their bearing on the number of bottom fishes in the neighbourhood are shown in the following details of typical hauls made at several different centres between Ponnáni and Malpé; the particulars are taken almost verbatim from field notes made at the time the trawl was hauled.

6. *Haul* 2, 23rd October 1908. Shot-trawl 10-40 A.M. in 15 fathoms, Narrakal bearing S. 86° E. Course N. by W. Hauled at 11-30 A.M. in 14 fathoms. Bottom all the way soft dark grey mud with a few small dead shells. Result :—1 scorpion fish (*Pterois russelli*), two small cuttlefish (*Sepia*), one small flat-fish (*Pseudorhombus arsius*) and a few small gastropod shells.

7. *Haul* 3, 26th October. Shot-trawl 8 A.M. in 7 fathoms, Calicut lighthouse bearing N. 81° E., 3½ miles, course west; hauled trawl at 8-50 A.M. in 13½ fathoms; bottom soft mud all the way with shells of a small hairy *Arca* and a pink *Tellina*. Result :—19 small fishes, mostly *Pristipoma guoraka*, a common species distinguished in Malayalam by the onomatopœic name of *Korrukurupen*, because of the loud croaking noise it makes when taken out of the water. None of these fishes were over 5 inches long. Current running north.

8. *Haul* 8, 6th November. From 10 into 12 fathoms, south-west of Calicut, 5 to 6 miles from land. Bottom, dark grey mud. Result :—Two adult *Psettodes irumei*, a stoutly built flat-fish, four young soles, 2 to 6 inches long, five small *Drepane punctata*, one silver pomfret, 23 small round fish of six species and one Ray (*Pteroplatea micrura*), 24 inches across disc. Also 14 prawns averaging 7 inches long and two cuttlefish (*Sepia*).

9. *Haul* 5, 6th November. Eight fathoms north-west of Beypore; bottom dark grey mud with dead shells of small *Arca*

and *Tellina.* Trawl one hour down. Results :—One Ray (*Pteroplatea micrura*), two silver pomfrets, one *Drepane punctata* and 20 mixed small round fish, also one cuttlefish.

10. *Hauls* 11 *and* 12, 9th November. Along 10-fathom line between Tellicherry and Cannanore; 4½ miles from land; bottom dark coloured mud with occasional dead shells. One hour haul in each case. Results :—Both hauls blank.

11. *Haul* 16, 10th November. 10 to 15 fathoms west-south-west of Cannanore; course west; bottom mud. Duration of haul, 1½ hours. Result :—Blank.

Haul 17. Going west from haul No. 16. 15 into 17 fathoms; bottom mud. Duration of haul, one hour. Result :—A blank haul.

Haul 18, 10th November. 25 to 27 fathoms; south-west of Cannanore, 14 miles from land; bottom, a sandy mud with a good many broken small shells and some polychaete tubes of mud agglutinated with mucus. Fishes caught :—Two large plaice-like flat-fish (*Psettodes irumei*), 17 and 12½ inches long respectively, one *Saurida tumbil* (nearly related to the "Bombay duck"), and two *Synagris* sp., 7 and 8 inches long. Trawl out one hour.

12. *Haul* 25, 12th November. 27 fathoms, due west of Cannanore. Bottom, dark grey mud with small dead shells in fair quantity, several species of small mud-dwelling polychaetes. Trawl out 45 minutes. Result :—two large *Psettodes irumei* (flat-fish), and one small *Serranus fasciatus*, a vertebra from a large whale, and several shells of *Murex*, *Rostellaria* and *Xenophora*, the last with numbers of other shells cemented to its whorls symmetrically. A number of that interesting fish *Bregmaceros macclellandi*, measuring 2 inches and under, were also taken.

13. *Haul* 34, 17th November. 13 fathoms south-west by south off Mangalore. Trawl down one hour; bottom, dark grey mud. Result :—a few round fishes of 4 to 6 inches long.

14. *Haul* 36, 20th November. Midway between Primeira Rocks and Caup Lighthouse. Depth 6 fathoms. Trawl down one hour 20 minutes. Bottom dark grey soft mud with dead shells. Result :—three small fish; five cuttlefish (*Sepia*).

15. *Haul* 46, 6th December. South-west of Ponnáni, 14 to 15 fathoms. Trawl down 1½ hours. Bottom, dark grey mud. Result :—A few mixed small fish including ribbon fish (*Trichiurus*), *Equula*, *Pristipoma*, and one *Psettodes*.

16. The above hauls are characteristic of the results obtained everywhere from mud bottom at depths of 6 to 30 fathoms along the Malabar Coast. In the shallower parts of this area we are on the fringe of the inshore feeding grounds of a number of species of small round fishes, while the hauls made in the deeper water usually gave signs of the presence of the plaice-like *Psettodes irumei*, a predaceous flat-fish which appears to be the only important bottom fish on muddy bottom in the area under notice.

17. The results obtained by trawling in the zones which bound the 10 to 30 fathom region both on the landward and seaward sides were frequently much richer, a consequence of the richer and more varied fauna of the bottom in both regions. Inshore, especially in the neighbourhood of river mouths, the bottom contains a varying admixture of sand; rocky patches, giving foothold and hiding to sedentary organisms, worms, and crustacea, are occasionally met with, while retarded inshore currents and the eddies formed by the projection of headlands provide conditions favourable to the concentration of swarms of neritic (inshore) plankton, especially of the smaller crustaceans as amphipods, copepods, ostracods and schizopods, which constitute in turn the lure directly for young and small fishes and indirectly for large species. In the vicinity of river mouths and in bays under the shadow of rocky headlands our trawl results showed rays and flat-fishes (Pleuronectids) to be thickly congregated, as far example off the mouths of the Beypore, Beliapatam and Mangalore rivers. Typical hauls made in these places, *i.e.*, off river mouths and in indentations of the coast, are the following:—

18. *Haul* 6, 6th November. In 7 fathoms west of Beypore river, mud bottom. Trawl down 50 minutes. Results:—A fine show of nine good sized Ray-fish (*Pteroplatea micrura*) and half a bucketful of round fish and prawns. The round fishes included two species of catfish.

19. *Haul* 10, 9th November. In 6 fathoms. Off the mouth of Darmapatam river, near Tellicherry. Haul between 8 to 9 A.M.; bottom mud. Catch:—Two large Ray-fish (*Pteroplatea micrura*), five good sized *Drepane punctata*, one black pomfret, 18 mixed round fish and a handful of prawns.

20. *Haul* 13, 9th November. Five fathoms south-west of Cannanore; bottom mud. Haul down from noon to 1 P.M. Catch:—7 *Psettodes irumei*, three large Ray-fish (one *Aetobatis narinari* and two *Pteroplatea micrura*) and 40 mixed round fishes. The *Psettodes*, dark coloured plaice-like flat-fish, were

of excellent size, none under 11 inches in length, while two were 16 inches long. In three instances these fishes had soles (*Cynoglossus* sp.) of 5 to $5\frac{1}{2}$ inches in length, in their stomachs.

A tow-netting made at this station showed the plankton to be excessively rich in copepods, and to contain a large number of fish eggs.

21. *Haul* 14, 9th November. 5 to $4\frac{3}{4}$ fathoms. South-west of Cannanore, course south-east from previous haul ; bottom mud ; duration of haul, one hour. Catch :—One large ray, two adult *Psettodes*, one 17-inch sole (*Cynoglossus*), three cuttlefish, and a considerable quantity of small round fishes.

22. *Haul* 19, 11th November. $4\frac{1}{2}$ to 5 fathoms. West of Cannanore. Bottom mud. Catch :—A fine ray, 3 feet across disc, a 13 inch sole, a quantity of crabs and large prawns, 5 to 6 inches long, and the usual show of small mixed fishes. The plankton at this station comprised a vast abundance of water-fleas (*Daphniae*) ; while *Euphausia* (a tiny shrimp) and fish eggs were present in large numbers.

23. *Haul* 20, 11th November. 5 to 4 fathoms. $2\frac{1}{4}$ to 4 miles north of Cannanore lighthouse ; one hour haul ; bottom mud. Catch :—Two hammer-head sharks, two large dog-fish, four large soles 15 to 16 inches long, with a bucketful of small mixed fish including three species of catfish. A vast abundance of water-fleas also characterised the plankton at this station.

24. *Haul* 22, 11th November. In 5 fathoms. South of Mount Dilly and adjacent to the mouth of Beliapatam river. Half hour haul. The catch was excellent consisting principally of large soles (*Cynoglossus* sp.) with a quantity of mixed round fish and prawns. The number taken is not known, as the majority escaped as the net was being hauled ; the fish had not had time to work down into the pockets.

25. *Haul* 23, 11th November. East of Beliapatam river mouth. 4 to 5 fathoms; bottom, mud. One hour haul. Current running north. Catch like that of haul 22 but richer, as we got 19 soles (*Cynoglossus* sp.) of 14 to 17 inches in length, two large rays (*Trygon bleekeri*), and a small lot of mixed round fish and prawns. The average weight of the soles was over half a pound.

26. *Haul* 29, 16th November. 8 to 10 fathoms. North-west of Mangalore river mouth. Bottom, soft dark grey mud with *abundance* of dead shells of small bivalves and gastropods including *Dentalium* in quantity ; the tests of small sea-urchins

REGISTRAR OF BOOKS REGISTERED MADRAS.

numerous; water discoloured. Duration of haul ~~one hour~~ 20 minutes. The catch amounted to a total weight of 55 lbs. made up as follows:—

	LBS.
Cuttlefish (*Sepia*)	14
First-class fish (chiefly flat-fish and pomfret) ...	16
Second-class fish	25
	55

27. *Haul* 30, 17th November. $5\frac{1}{4}$ to $5\frac{1}{2}$ fathoms, beginning from two miles south-west of Mangalore river, thence going southwards. Plankton abundant. Enormous shoals of sardines present. Bottom, sandy mud; water discoloured with sediment; strong ebb tide from river mouth. Duration of haul three-fourth hour. The catch amounted to 68 lbs.; weight made up of flat-fish (*Psettodes*) $4\frac{1}{2}$ lbs.; small round fish 12 lbs.; three rays and two dogfish $51\frac{1}{2}$ lbs.; total 68 lbs. The rays were *P. micrura*, while the dogfish were the highly esteemed *Chiloscyllium indicum*.

28. All these hauls gave an encouraging show of fish especially when we bear in mind that the size of the trawl was extremely small and that a trawling smack, to say nothing of a steam trawler, would use a beam at least twice as long, thereby more than doubling the potential catching power, because when using a small trawl such as ours, the chances of a fish escaping when disturbed by the ground rope are greater than with a wider mouthed net; in the one case if a fish dart sideways, say 8 feet, it may pass clear of the net, whereas in the case of a larger net, the same startled flurry would not take it clear of the side of the trawl mouth and it would be passed down into the cod end. Again, crews of trawling smacks after working one locality for some days would discover the places where fish congregate most numerously and by working on selected fishing grounds would obtain further improved returns. Another point in favour of better catches by smacks than our returns indicate, is that whereas all our inshore trial hauls were daylight ones, smacksmen would be prepared to work at night and as we know from European experience night trawling generally gives better results than by daylight. Everything is in favour of a great increase in the bulk of the catches if a larger trawl be worked from smacks and when we consider that several of our hauls gave satisfactory catches even under the unfavourable conditions under which we laboured the prospect of developing a profitable *inshore* trawling industry on the Malabar and Canarese coasts is sufficiently promising to justify effort and capital being put into a working trial of the business

were it not that the establishment of such a fishery would be likely to prove detrimental to existing inshore fisheries, more especially to the sardine industry. This might be occasioned both by (*a*) an active interference by hampering the canoe fishermen while occupied in shooting and hauling their nets and (*b*) by disturbing the bottom. We shall see in the third section that the evidence gathered during our cruise tends strongly to show that Indian sardines feed upon or close to the bottom and therefore any extensive disturbance of the diatomaceous scum flourishing thereon would probably entail disastrous effects upon this most important industry. The further investigations contemplated should furnish sufficient data to determine this matter definitely and if my fears be confirmed, it may be advisable eventually to pass a regulation prohibiting trawling within inshore waters.

29. The narrow zone between the 30-fathom line and the edge of the submarine cliff which abruptly demarcates the seaward limit of the shallow-water shelf or plateau margining the coast remains for consideration; unfortunately the *Margarita* proved quite unsuitable for deep-water dredging and we were able to make but a few hauls, and these in no greater depth than 40 fathoms. However as the bottom along the edge of soundings, say between 40 and 90 fathoms, appears from the chart to consist of much the same variety of bottom as we found between 36 and 40 fathoms—fine sand with shells, stones, and an occasional patch of rock—it is to be expected that the same faunistic results will prevail generally over such area.

30. What we found was that wherever bottom of intermingled sand, stones, and rock occurs between the 30 and 40 fathom lines, decapod crustaceans and gastropod molluscs are exceedingly abundant with a show of small rock fishes (*Serranus* spp.). The great variety of crustaceans is most characteristic; every haul made brought up large numbers of two species of swimming-crabs, while the bastard or broad-headed lobster *Scyllarus* and the strange brown velvet clothed ball-crab *Dromia*, were numerous. No samples of rocky bottom were obtained although on one occasion we had unwelcome evidence of its presence in a badly torn trawl net. The larger material lying on the bottom consisted principally of dead shells increased in size by accretion, the bygrowth over and upon them by massive colonies of polyzoa, small oyster shells and worm tubes. In one haul we brought up a large fragment of furnace slag measuring 8 by 8 by 4 inches, evidently thrown out from some passing steamer.

Sea-fans, sponges, zoophytes and echinoderms, so common on hard bottom on the eastern coast, were practically absent;

no large fishes were taken although a large number of small ones, rock-fishes (*Serranus* chiefly) and spotted soles (*Cynoglossus*) were present in most hauls.

31. Summarizing results the main conclusions I draw are—

(*a*) That the shallow inshore zone bounded by the 6-fathom line is sufficiently rich in many localities to support a profitable trawling industry conducted by sailing smacks, were it not that such would probably be harmful to more important existing interests; the principal bottom fish numerous in this zone (during November) are the fine predaceous flat-fish *Psettodes*, running to a length of 17 inches, soles (*Cynoglossus*) of the same size, large rays of the genera *Trygon* and *Aetobatis* together with the smaller but more abundant *Pteroplatea micrura*, hammerheaded sharks, dogfishes and a variety of small round fishes. Cuttlefish and prawns may also be taken in abundance in the trawl in many places in this zone especially in the neighbourhood of the larger river mouths.

32. (*b*) The median shallow water zone bounded respectively by the 6-fathom and the 30-fathom line is quite unfitted for profitable trawling operations. The bottom is uniformly composed of a soft dark grey mud supporting a most meagre invertebrate fauna. The only fish at all plentiful here is *Psettodes irumei*, but although the majority of hauls on this ground attested its presence, its numbers are too few to make trawling profitable. As an example of the sparseness of life on this bottom, trawl haul No. 35 at a depth of 22 to 26 fathoms produced only 13 of these fishes, although the trawl was down 5¼ hours! The remainder of this catch consisted of 12 lbs. of cuttlefish and one pound weight of mixed small round fishes.

33. (*c*) Outside of the 30-fathom line trawling conditions improve greatly, the bottom becomes firmer and is largely composed of fine grey sand, with more or less admixture of mud, shells and stones. Crabs, squat lobsters (*Scyllarus*) and fairly large gastropod molluscs abound and large fishes ought to be plentiful. Their existence in quantity has yet to be proved, as the means at our disposal on the *Margarita* cruise were inadequate.

A better sea-boat fitted with a suitable trawl-winch and appliances, and operating a larger sized trawl are essential to a definitive test. Personally I am now inclined to think it probable that this zone, which has an average breadth of 25 miles and extends the whole way from Cochin to Kundapur, a distance of 260 miles, would prove profitable if worked by a full-powered steam trawler. From what I know of bottom of similar physical character (fine grey sand) elsewhere on the

Indian coast, I believe that with a large trawl towed at a sufficiently high speed, large numbers of the so-called Indian cod (*Serranus* spp.), of rock-fishes (*Lethrinus* spp.), and of sharks and rays would reward the enterprise. But even if a sufficiency of fish be obtainable, the difficulties which surround the question of the profitable disposal of the catches will remain for solution, and in my opinion it is more easy to trawl fish than to organize the distribution and sale section of the enterprise. Trawl fish to pay should be sold fresh ; if curing be necessary then expenses may be so heavy as to render the enterprise profitless.

B.—The development and extension of drift netting and long-lining.

34. *Drift nets.*—Drift netting has long been practised on the West Coast both in Malabar and South Canara where it provides employment for a large number of men. Development has, however, been markedly unequal in the two districts, for whereas in South Canara, thanks to the energy and enterprise of Ratnagiri fishermen, progress has been steady and satisfactory on lines surprisingly akin to those followed in the North Sea by our own herring drifters, on the Malabar coast, on the contrary, the industry has suffered arrestment at a very early and imperfect phase and may be characterized as in an arrested embryonic condition, capable of no improvement without a complete revolution in the design of the boats employed in this fishery. In the case of the Ratnagiri men the dug-out canoe has been definitely abandoned as wholly unsuitable, its place taken by true boats, large, well designed and well built, able to go far to sea and to accommodate that great length of nets which is necessary in order to ensure catches sufficiently large to prove really remunerative. In striking contrast to this enlightened policy is opposed the touching fidelity of Malabar to its dug-out canoe, a type of fishing craft the worst possible for the prosecution of drift netting on any but the most paltry scale. It is not as if the value of drift netting as one of the principal methods of sea fishing were little known or appreciated in Malabar ; on the contrary in a primitive way it is practised by the men of every fishing village on the coast, and its importance in their eyes is demonstrated by the fact that there are more varieties of gilling nets in use in this district than of any other net type. The difficulty or rather the impossibility of further development is due solely to the fact that the smallness and unseaworthiness of the fishing canoes in use set inexorable limit to the size of the nets employed and the distance from

land at which they may be used. This bond of the dug-out must be broken before progress can be resumed.

35. The present condition of drift-net fishing on the Malabar coast may be summarized by stating that of drift nets properly so-called (Ozhuku vala being the generic Malayalam term), there are six varieties in ordinary employment, namely, tirandi vala, valia sravu vala, elam sravu vala, nariyam vala, odu vala and kandadi vala. The respective dimensions and uses may be tabulated as follows:—

CLASSIFICATION of Malabar drift nets (Ozhuku vala).

No.	Name.	Fishes chiefly caught.	* Approximate size of meshes.	Remarks.
1	Tirandi vala ..	Large rays (Rhinobatidæ and Raiidæ).	16 fingers or 12 to 16 inches.	Average size of mesh 13½ inches.
2	Valia sravu vala ..	Large sharks and sawfish.	14 fingers or 11 inches.	The cord very strong, thrice as thick as that of the tirandi vala.
3	Elam sravu vala ..	Medium sized sharks.	12 fingers or 8½ to 9½ inches.	Ayakora = *Cybium guttatum and C. commersoni.*
4	Nariyam vala ..	Largest sized seer (ayakora), sharks, palamin and kora	10 fingers or 7½ to 8 inches.	Palamin = *Chorinemus lysan.*
5	Odu vala or valia kandadi vala.	Medium sized seer.	8 fingers or 5½ to 6 inches.	Bamin = *Polynemus, spp.*
6	Kandadi vala ..	Small seer (varimin), bamin, valai, catfish, dogfish.	4½ fingers or 3¼ to 3½ inches.	Valai = *Chirocentrus dorab.* Kora = *Sciæna spp.*

* The size of mesh is measured from end to end with the mesh stretched lengthwise: the size given is equal to twice the length of one side from knot to knot.

36. These nets are made in short lengths or pieces as in England, a number of pieces being mounted end to end when preparing the nets for use. The length, breadth (depth), and number of these pieces are extremely short when compared with what is customary in Europe; though the dimensions are somewhat variable according to the particular ideas of each fisherman or community, the length and breadth of Malabar "pieces" are usually not more than 7½ fathoms by 2½ fathoms stretched measure, or about 5 fathoms by 10 to 12 feet when measured spread on the ground. The kandadi vala is said to be made sometimes double the length of any of the other nets, but the one I measured at Beypore was the usual 7½ fathoms by 2½ fathoms stretched measure, with a mesh of 3¼ inches and floats of light wood (sticks) attached three feet apart.

37. The usual number of pieces constituting a "fleet of nets" is from 8 to 10, usually 8. All are made of fibre (hemp) and are barked. The head rope is thin and made of coir.

As suspended in the water when set, a fleet of eight of these nets, the usual complement of one canoe, is less than 60 fathoms long, stretched measure, and forms a curtain or wall of net not much more than 12 feet in depth. Compare this with the 16 to 100 nets operated by British drifters engaged in the herring fishery, each of which is from 25 to 30 fathoms long by a depth of $4\frac{1}{4}$ to $4\frac{1}{2}$ fathoms, averaging from 1,000 to over 2,500 fathoms when stretched and giving a working length of from a mile to a mile and a half when mounted. In the case of mackerel the length is even greater, extending to as much as $2\frac{1}{2}$ miles; with these nets however the depth is decreased to 2 or $2\frac{1}{3}$ fathoms; so that the total weight and area of fleets of these two descriptions of nets when used by boats of the same size, appoximate fairly closely.

38. In case it be said that it is invidious to make comparison with nets as employed in Europe where conditions may be very different to those prevailing on the Indian coast, the answer lies in what Ratnagiri fishermen are doing on the Canarese coast. At Mangalore and at Malpe any time between October and March, these men may be seen putting to sea with a fleet of nets in each boat 40 in number, each measuring from 27 to 35 fathoms long (stretched) or a total of from 1,080 to 1,400 fathoms; the actual length when set averages about *three quarters of a mile.* The comparison is well brought out in tabular form thus :—

COMPARISON of the dimensions of Indian and British drift nets.

Locality.	Name of net.	Size of mesh in inches.	Number of nets in a "fleet".	Depth of each net in fathoms.	Length of each net in fathoms.	Total length of fleet as set.
Malabar.	Odu vala.	$5\frac{1}{2}$ to 6.	8 to 10 (usually 8).	2	$7\frac{1}{2}$	About 50 fathoms.
Malabar	Kandadi vala.	$3\frac{1}{4}$ to $3\frac{1}{2}$.	8 to 10 (usually 8).	2	$7\frac{1}{2}$	About 50 fathoms.
South Canara (used by Ratnagiri boats).	Vowri (for bonito, seer and shark).	$4\frac{1}{4}$ to $4\frac{1}{2}$.	40	$2\frac{1}{4}$	27 to 35.	$\frac{3}{4}$ to 1 mile.
Great Britain.	Herring net.	2	16 to 100.	$4\frac{1}{4}$ to $4\frac{1}{2}$.	20 to 30	1 to $1\frac{1}{2}$ miles.
	Mackerel net.	$2\frac{1}{2}$	100 to 150.	2 to $2\frac{1}{2}$.	20 to 30	$2\frac{1}{2}$ miles.

39. The appliances, methods, and boats employed by the Ratnagiri men are open to considerable and many improvements, some of which will be touched upon later, but even as they exist now their superiority to Malabar methods and gear is so marked as to be beyond comparison; the former are

designed on sound lines readily capable of adjustment and development to meet new requirements or to operate on a greater scale; the latter are limited to their present trivial development owing to the restraint imposed by use of dug-out canoes as the sole form of fishing craft employed. An improved type of boat must be adopted in Malabar waters before progress can be resumed, but those methods which Bombay fishermen find successful should be within the capacity of Malabar men to emulate now that the demand for fish, both cured and fresh, is expanding rapidly in consequence of increase of population, improvement in the economic condition of the masses, and, more particularly, improved and accelerated means of steam transport and distribution. With improved methods of curing the demand for cured fish especially is capable of enormous increase, and the employment of drift-net boats of an improved Ratnagiri type is the best way to obtain the requisite supplies; in doing so such boats would tap what is to all intents and purposes a new source of supply, because south of Mount Dilli, the offshore waters, say from 7 fathoms outwards, are untroubled by the fisherman. In addition, drift netting for sharks would confer great benefit on other fisheries; these fish swarm off the Malabar coast and as many are predatory, following and feeding upon shoals of smaller fishes, the havoc they cause is enormous. Even when they do not gorge upon fishes, they compete with them for their food-supplies, for the shoals of small crustaceans in the waters, and for the worms, burrowing prawns, and other creatures of the bottom preyed upon by the bony fishes. Every boat load of sharks brought in must be considered not simply as so much weight of food and fish oil, but as the removal of so many destructive enemies and active competitors of the more valuable food fishes.

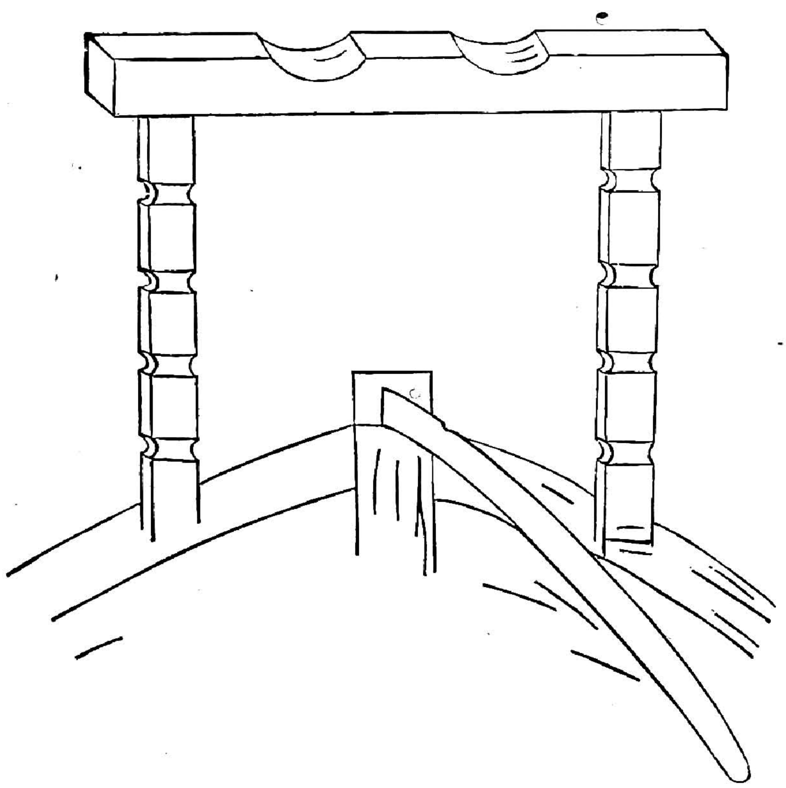
40. The concession recently made by Government in response to the representations of Sir F. A. Nicholson, of allowing issue of cheap salt to boats engaged in deep-sea fishing removes a great obstacle to the successful conduct of deep-sea drift netting on an enlarged and extensive scale, and will remove the great objection made in the past to the employment of Ratnagiri methods in the shark fishery by certain curers who state that the catches brought ashore by the Ratnagi boats are frequently (usually) more or less putrid and infested with maggots, faults due entirely to faulty curing entailed by the employment of salt in insufficient quantities.

41. Before concluding this section upon the prospects of drift netting on the Malabar coast, it will be useful to state exactly what Ratnagiri methods at present are. To explain this, I cannot do better than detail some personal observations

made during a night at sea with one of these boats fishing from Mangalore.

42. As is the usual practice, the boat in question left port early in the afternoon. After clearing the river mouth a west course was steered at a speed of about 5 knots with a favourable light breeze. At the end of $1\frac{1}{2}$ hours run the course was altered to south and continued without change till 5-30 P.M. when soundings showed the depth to be 13 fathoms, sand bottom, the distance from land being about 7 miles. The tindal intimated that the nets would now be shot. One hand took charge of the head line with its row of wooden floats, while another took up the foot of the net which lay neatly piled in the waist of this shallow low-freeboard boat, which, having no deck, is without separate net-room accommodation. The nets were rapidly paid out over the side, the boat running south by east the while. When the last of the "fleet" was shot, the boat was brought up into the wind, 10 to 15 fathoms of warp paid out, sail furled and then first the yard and then the mast itself were lowered aft till they rested on a rectangular crutch at the stern above the tiller.

Fig. 1.



Crutch over stern to take mast and yard, Ratnagiri fishing boat.

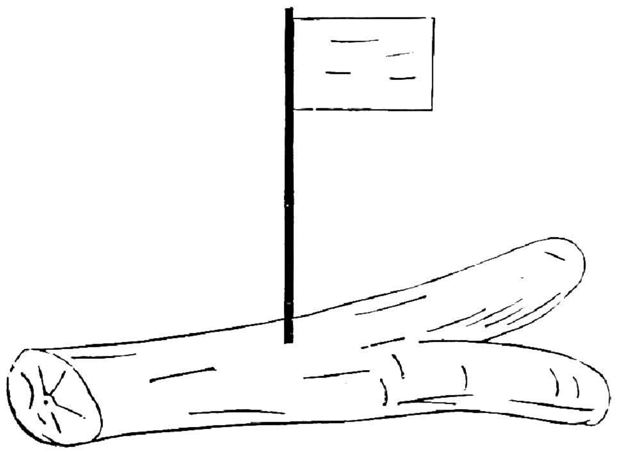
The last of these operations was completed as the sun sank below the horizon when the men prepared to make themselves comfortable and take a rest till 8 P.M. when the first examination of the net usually takes place.

43. The net used during this season, October to January, is the *vowri*, a light hemp net having a mesh of $4\frac{1}{4}$ inches. It is usually made up of 40 pieces, each piece when mounted being from 20 to 27 fathoms in length, by about $2\frac{1}{4}$ fathoms deep.

The head rope, made of coir, is well buoyed with very numerous wooden floats of cylindrical form and is marked at one-third and two-thirds of its length by a large Y shaped wooden buoy carrying a small flag. These buoys measure three feet over all.

To resume the account of the night's operations; at 8 P.M. the little outrigger canoe which these boats carry for the purpose was launched over the side and three men paddled away along the line of net now streaming north-westwards into the wind. As the canoe passed along the net two men leaned over the side, the one gathering in the lower edge of the net and the other dropping it back after examination. This examination was made again three times during the night. Soon after sunrise the net was hauled and after being re-stowed in the waist and the last fish gathered up, mast and sail were raised and the run home commenced. On the way back a certain proportion of the fish is usually gutted and cleaned, but complaint is sometimes heard from the contractors, who receive the fish, that this gutting is largely neglected with the result that by the time the boats deliver their catches, from 11 A.M. until as late as 3 P.M. if the wind be light or adverse, the condition of the fish is anything but good. The value of a steam or motor carrier or of motor power in the fishing boats themselves is clearly indicated here.

Fig. 2.



Flag buoy on Ratnagiri drift-net.

44. The fish brought in by these boats consists principally of seer, bonito, palamin (*Chorinemus*), catfish, sharks often of large size, together with occasional sword-fish, also *Rhinobatis* and other rays.

45. The boats used by Ratnagiri fishermen are of three kinds, the two smaller, used in the vowri net fishery, returning to port daily; the larger used in the deep-sea shark and ray fishery which lasts from January to March. The net used by these larger boats is called Vavuryala balai, a large edition of the Malabar srávu vala, of large mesh and stout twine. In pursuit of their prey these boats have to go considerable distances from land and even to the limit of soundings, the 100-fathom line. They keep the sea continuously for periods

varying from three to seven days according to the success obtained or the character of the weather. The fish caught during the voyage are gutted and split by the crew and sprinkled with a most inadequate amount of salt supplied to the men by the contractors to whom they hire their boat and their services.

46. Successful as are the two Ratnagiri drift fisheries there is room for improvements in several directions in regard to each; the care and the preparation of the catch require more careful attention; especially is the use of more salt absolutely necessary in the case of the deep-sea industry; special receptacles should be designed and introduced for the proper stowage of the fish; if partially or, better still, wholly decked, the boats would be able to extend their working radius and exploit new grounds, and if this were done, mechanical means in the form of a small capstan might be introduced to reduce the labour involved in hauling great lengths of net, an improvement which would be of further benefit by enabling the men to use larger fleets of nets than at present possible; with decking and possibly some enlargement of the boat herself, fleets of several different nets may be carried for use when shoals of smaller fish be met, the vavuryala mesh being too large to capture seer and bonito; finally if motor power were installed and the working cost kept low, greatly increased catches would result in the course of a season as the boats would be independent of the calms and light and adverse breezes which so often hamper them as sailing craft, and the condition of the catches when landed would be benefited correspondingly.

47. The extension of the fishing radius is perhaps the most important advantage to be gained by increasing the sea-going and sea-keeping qualities of these boats. During the cruise among the Laccadive Islands made subsequent to our visit to Mangalore, extensive grounds, which are undoubtedly very rich in fishes of all sizes—sharks, sword-fish, rock-fishes, bonito and flying-fishes—were seen in several localities; the great bank, carrying depths of 8 to 25 fathoms, south of Ameni, and that north of Androth appeared particularly attractive but are as nothing in comparison with the enormous bank called indifferently Bassas de Pedro, Munyal Par, or Padua bank, which extends for a distance of 70 miles north and south, has an average breadth of quite 12 miles, with hard bottom of sand, shells, and coral at a depth of 22 to 28 fathoms, conditions particularly well suited to make it the resort of a great abundance of fishes. As it lies off Mangalore at a distance of fully 100 miles only well-found sea-going boats will be able to fish there. Should this Government acquire a Fisheries Inspection vessel answering this description, a working

experiment on this bank should be marked out as an important item in the programme of her duties.

48. Reverting to a comparison of drift-netting as carried on in Malabar and South Canara waters, it has now been made clear, I think, from the facts detailed, that in the former district opportunity offers for expansion on an extensive scale of drift-netting operations by the introduction either of boats and nets as used by Ratnagiri men further north (the physical and faunistic conditions of the sea and sea-bottom are similar in both districts) for the development of the inshore grounds, and of decked boats for the off shore grounds. In the case of the inshore boats, those resorting to port daily, not only is it certain they would have success with the vowri in fishing for what may be called medium sized fish, but by drift nets of smaller size with a 2-inch mesh, they should net great quantities of mackerel (aila = *Scomber microlepidotus*) usually very abundant during the cold weather on this coast. In years when mackerel and sardines do not resort to inshore waters, these boats would be particularly useful; they would probably be able to save the situation and turn a bad season into a fairly prosperous one by seeking the shoals in deeper water where at present the crank canoes, good enough for work in smooth water close inshore (within the 5-fathom line), are not able to go. Here I may mention a valuable experience in regard to this disability gained during the "Margarita's" cruise. In order to test whether this disability might be overcome by the use of a launch to tow canoes to and from fishing grounds in deeper water, it was arranged for the "Margarita" to tow two canoes, manned by 14 men and provided with a set of drift nets to a greater distance from coast than they ever go. We left Calicut at 3–30 P.M. and proceeded due west, stopping at 5–40 P.M. at a point 6¾ miles from land with soft mud bottom, 13 fathoms. Here the canoes cast off and shot their net at 6–15 P.M. a moderate north-west wind blowing and the sea slightly disturbed. At 10–45 P.M. when there was somewhat less wind and sea, one canoe returned and reported that at 8 o'clock there was too much sea to permit of hauling the net and that they were unable to do so till nearly 10 o'clock. They refused to shoot the net again.

49. As the second canoe did not return (she missed the steamer and found her way to shore eventually) we had to drift about till daybreak. At that time the wind and sea had improved considerably, the weather quite as good as that in which excellent results are obtained by drifters in the North Sea. All the same the canoe men regarded the weather as "bad", they averred that they could not resume work unless

there was very considerable further improvement, and that there was too much wind and current. As actually gauged by observations our drift was one knot per hour. In the hope of making further trial we edged further out to sea till at 4 P.M. we were 32 miles from land with a gentle breeze blowing and moderate sea. At 5-15 P.M. the men wished to cast off and try again but Captain Heycock, who was in command of the steamer, considered it would be difficult to find the canoe after dark in which case the men's position would be dangerous and could not permit this. After some persuasion the men agreed to shoot the nets from the canoe while in tow of the drifting steamer but almost immediately after this was done the men called out that their head-rope was breaking under the strain of the steamer's drift and let go the tow rope; on account of the danger to which their canoe was exposed, they were taken in tow again as soon as possible and they refused to try again. The conclusions to be drawn from this experience are clear that canoes are quite unsuited for drift netting beyond the lee of the shore, that the present nets are too short and weakly mounted to be used from larger boats, which must have nets proportioned in strength and length to their size in order that their drift under the influence of wind may be more or less counterbalanced by the drag of the nets and the warp. Of course this last fact is a matter of common knowledge at home, but I wish to emphasize it here for the benefit of those who may wish to develop drift netting on the coast of India. The great value of a motor fitted into a moderately-sized drifter for the purpose of easing strain on the nets by heading towards them when wind-drift is too great, is a most important advantage of such an installation, although the primary use is in conferring independence of winds and calms in going to and from the fishing grounds.

50. *Long lining.*—If local statement may be relied upon this fishery as now practised on the Malabar coast arose by a process of independent evolution during the last twenty-five years. Certainly it has not been practised many years whatever may have been its origin, whether by local evolution or by introduction from another district or country. Its rise and development hold out much encouragement to those concerned to improve fishing methods as they afford practical evidence of a spirit of progress and enterprise among some sections of the fishing community. At the present time line-fishing is practised at the principal fishing centres along the west coast and it is significant that these liners are all Moplahs.

51. Two descriptions of lining are practised, cheria béppu, or small hook trots, and valia béppu, lines armed with large

hooks. The former are usually about 600 fathoms long with hooks attached every $1\frac{1}{4}$ fathoms by 9 inch snoods. Five hundred hooks are about the maximum in use. The fish caught are chiefly catfish, seer, palamin (*Chorinemus*), kora (*Sciaena*), katuwa, dogfish and rays. The bait employed consists of sardines, mackerel, and other small fish which are purchased from net fishermen. Small canoes manned by two men are exclusively used in this fishery; they leave shore at daybreak and reach their fishing ground generally between 8 and 9 A.M. returning home in the afternoon.

52. The fishes sought after by the large hook long-liners are limited almost entirely to sharks of large size. The line used is short, from 100 to 200 fathoms in length, the hooks being suspended at 10 fathom intervals from the ends of jointed ironwire snoods about $1\frac{1}{2}$ feet long. Stout home-made hooks are used, measuring from 8 to 10 inches in length and are baited with large pieces of other fish, more especially dogfish; beef is also said to be used when procurable at sufficiently low price. The same small canoe as used by the small hook liners is favoured, manned by two men or by three as maximum; one reason why they prefer a small to a large canoe is that a large shark is more difficult to load into a high-sided large canoe than into a small one. A small canoe may be canted over and the shark slipped in; if need be the men jump overboard, submerge the canoe and bring it under the shark, subsequently baling out the water—a similar plan to that recently adopted in one of the home graving docks to load a large submarine aboard the ship that was to convey her to Japan.

53. The shark liners proceed further seawards than any other fishermen on the West Coast with the one exception of the Ratnagiri men; several times we met them between 6 and 7 miles from land fishing in depths of 16 to 20 fathoms. They claim to go further seawards but we never saw them any more than 7 miles out, the distance carefully ascertained by compass bearings. Even fishing at this distance is of comparatively recent adoption; I was told that this "deep-sea" shark lining has not been practised for more than six or seven years.

54. Considerable as has been the development of this method of fishing, it compares unfavourably with long lining as carried on in Europe where, instead of the paltry 500 hooks arming a Malabar trot, a long line may extend to five or six miles in length and carry from 5,000 to 6,000 hooks.

55. As with the present drift-net fishing in Malabar waters, long lining having reached a certain stage of development is unable to make further progress because of the limits imposed by the small size and crank nature of a dug-out canoe for operations on a more extensive scale than the present. The industry has reached the limit of development capable under present conditions and no advance can be made till the advent of larger and more weatherly boats. The shark fishery particularly appears to offer immense opportunities for development if long lines be used from larger boats. With such boats, seer-whiffing after the Sinhalese fashion, employed on the way to and from the shark grounds, should prove a profitable and easily carried on addition to the ordinary operations. With a large boat carrying a stout mast the objection of the liners to use a larger craft (in the form of the big size of canoe) would vanish, for lifting tackle from the mast head would furnish the means requisite to heave even the biggest sharks aboard. Seagoing boats would also permit of efforts being made to develop pelagic fisheries in the neighbourhood of and also beyond the 100-fathom line for bonito, flying-fish and swordfish more especially. Bonito we see caught by the Ratnagiri men in fair numbers in their vowri drift nets, we know they are speared in the Laccadives, and that the bonito fishery forms a great and profitable industry and the chief employment of the islanders at Minicoy and in the Maldives, but from the experience of the Japanese and the Maldivians hook and line in conjunction with live bait appears to be the most killing method. The possibility of founding and developing a great bonito fishery is sufficiently tangible to warrant a determined and sustained effort being made when a suitable boat, such as the projected 40-foot fishing lugger to be built for the Fisheries department, is available. A peculiarly favourable factor which makes largely for the eventual success of the suggested investigation is the ease with which the necessary live bait (sardines) may usually be procured on the West Coast. Should the attempt be decided upon it will be desirable to engage a couple of Maldivians skilled in this particular fishery to furnish the requisite technical advice and to teach the art to the regular crew, they in turn being instructed by the officers of the department how to improve their present imperfect curing methods. Indeed there is much to be said in favour of having a complete crew of Maldivians, men from Minicoy preferably as they belong to the Collectorate of Malabar; these men are born sailors and fishermen, and as they frequently take service aboard steamers in the Indian coasting trade they have not

that objection to far-away voyaging which characterises so many Indian fisherfolk otherwise suitable.

56. A seagoing experimental fishing boat would also be able to test various methods for the capture of the flying-fish which abound so greatly beyond soundings. Floating trots baited after the Laccadive manner and the Negapatam screw-pine lure would both be tried, together with others which are under consideration. In actual work, in order to expedite the operations, several fishing methods may be tested simultaneously, for example, shark-trots, bonito-trots and flying-fish lures are all capable of operation at one and the same time, while seer-whiffing may be tested on the way out and home.

57. *Fish-wells.*—Line-caught fish are particularly well suited to be taken ashore alive. Unlike trawled and drift-netted fish they suffer no serious injury in the process of being caught and may be transferred from the hook to a "well" aboard the fishing boat or to a live car without hurt, and in either of these receptacles may be conveyed to port and kept for a reasonable time till required for market. Naturally prime fish so treated would command excellent prices and would come in most usefully whenever a short spell of bad weather prevented boats from putting to sea. Kora (*Sciaena*) and such genera as *Lutjanus*, *Serranus* and *Lethrinus*, fish likely to be caught in quantity, and all tolerant of handling and some amount of knocking about, are particularly suitable for carriage alive in wells and cars.

The determining influences which control the migrations of sardines and mackerel on the Indian Coast.

58. It is matter of common knowledge that the supplies of both sardines and mackerel exhibit enormous and at present inexplicable fluctuations from time to time in the Malabar and South Canara fisheries; sardine shoals in particular are known to be peculiarly variable in their distribution through the years whereof we have any records, in some seasons being so prodigiously abundant that 34,000 tons of their dried bodies may be exported in one year, *e.g.*, 1907–1908, after all food requirements for fresh and cured fish have been satisfied, the latter accounting for upwards of a quarter of a million maunds in a prolific year, while in other seasons the supply falls away so utterly that not a ton of fish is made into manure. In such years of dearth the amount cured may fall as low as 28,702 maunds (1898). To compile data from past records sufficiently extensive and reliable to be of real value in an investigation of the factors determining

these fluctuations would be an extremely difficult and unsatisfactory task; it would also be one of doubtful utility both on account of the many lacunæ in the information available and because of the complete lack of correlated and contemporaneous records of those biological and hydrographic conditions which we presume to be intimately concerned in influencing the periodical movements of migratory fishes. To arrive at a serviceable explanation of the problem we shall have to obtain intimate knowledge and keep systematic record of the relative seasonal abundance of plankton both in bulk and in detailed constitution within the areas under investigation, of the weather conditions prevailing at the same periods and places, the clearness or the turbidity of the sea at the times when shoals are numerous and of the direction of the inshore drift at the critical periods; particular attention must also be paid to ascertaining with exactitude the proportion in which different organisms contribute to the food of sardines and mackerel respectively so that this may be compared with the constitution of plankton collected simultaneously.

The conduct and results of such investigations will be particularly important and illuminative in seasons when sardines or mackerel appear to desert inshore waters. In such a year besides the scientific investigation and record of biological and hydrographic conditions, exploration of the deeper zones outside the ten-fathom line in search of the missing shoals should be prosecuted with unremitting energy in view of the great economic importance of a solution of this question, to say nothing of its intrinsic scientific interest.

59. The vast importance of the sardine and the mackerel to the fishing population of Malabar and South Canara as well as to the coast populations of Ganjám, Vizagapatam and Tinnevelly districts on the East Coast cannot easily be overestimated, in as much that they have sometimes been dubbed *kudumbam pularthi*, " the provider for the family ". The great industrial value of the two fisheries in question may be gauged in some degree from the figures of the quantities treated in fish-curing yards during the period 1896 – 1908 shown in the table which follows this paragraph. It must also be borne in mind that an additional quantity, which probably approximates to at least one-half of the average of these years goes into consumption in the fresh condition, and that a relatively enormous surplus is turned into manure after the food market is fully satisfied in those years when sardines are exceptionally abundant as for example 1906–1907 and 1907–1908 when quantities approximating to 12,000 tons and 34,000 tons respectively were exported from

Malabar and South Canara ports in addition to the smaller quantities used in India itself on coffee and tobacco plantations.

60. Table of the quantities of sardines and mackerel treated in the fish-curing yards on the Malabar and South Canara coast from 1896, also of the quantities of sardines cured on the East Coast of the Madras Presidency since 1900.

(Compiled from fish-curing yard returns.)

Year.	Malabar and South Canara.		East Coast.
	Sardines in maunds.	Mackerel in maunds.	Sardines in maunds.
1896	387,295	253,857	..
1897	253,649	90,365	..
1898	28,702	401,946	..
1899	A poor year for sardines.	Returns not available.	..
1900	57,880	238,500	75,000
1901	137,190	828,000	11,000
1902	219,760	588,500	45,000
1903	185,160	263,050	24,000
1904	133,200	292,550	29,000
1905	126,080	339,000	40,000
1906	148,259	34,030	45,000
1907	279,821	260,200	85,692

In 1907 sardines were more abundant than they had been since 1896, and it is noteworthy that the mackerel fishery was a failure in 1897 and 1906, in the one case a year succeeding, in the other, one preceding a phenominally good sardine season.

61. During the *Margarita's* cruise particular attention was paid, so far as circumstances would permit, to the lines of enquiry enumerated above; a large number of observations, experiments and collections were made at sea and much information collected from Salt Department officers, fishermen and curers when in port, which has enabled a considerable amount of progress to be made in clearing up a number of important preliminary questions, so that we are enabled to see much more clearly the chief lines of investigation on which work in future should be concentrated.

62. The large bulk of material collected, plankton, stomach contents, and samples of sea-bottom, will require considerable time to identify, analyse, and tabulate, and little can be said in detail about them at present; general facts and observations are more easily dealt with, and in order that a foundation be

laid on which future work may more readily be built, I shall now give an outline of the more important observations made and data collected, premising that such are admittedly imperfect and subject to revision when further information be available.

C.—The spawning season and migrations of Indian Sardines.

63. Excluding the anadromous Hilsa (*Clupea ilisha*), the three most important members of the herring family in Indian waters are the three sardines: *C. fimbriata*, *C. longiceps* and *C. lile*; of these the two first are by far the most important being respectively the *chala matthi* and the *nalla matthi* or "oil sardine" of the Malabar coast and the *buthai* and *erabai* of South Canara.

64. The oil sardine (*C. longiceps*, Cuv. et Val.) is of the greatest value for many purposes; it is used extensively as food in the fresh and the cured condition, is the source of an excellent oil invaluable in the jute industry and considered a great specific when smeared over their boats by West Coast fishermen and boatmen against the attacks of the ship-worm; as fertilizer for tobacco, coffee, tea and other crops the excess over local requirements is employed largely in years of superabundance when it is shipped abroad extensively, principally to Ceylon and Japan. It is also noteworthy as the species best suited for canning.

65. On the West Coast of India this sardine appears in quantity during normal seasons towards the end of June. Shoals arriving at this period consists entirely of adult individuals with the reproductive products, roe and milt, well advanced; shoals with ripe roes continue to be met with even till the end of August. The spawning period is one of considerable duration and it appears certain that there is considerable variation in the date at which the gonads arrive at maturity in the members of separate shoals. It would seem, indeed, that the shoals arrive inshore in the order at which these gonads ripen; that those sardines whose gonads ripen first, are the earliest arrivals and the rest in order of maturation of their reproductive products.

66. Fry of 1 inch in length have been noticed at Calicut towards the end of July, while I have record of a large catch of very small oil sardines averaging $1\frac{1}{2}$ inch long, at Tellicherry on 6th August 1908; on the day preceding the capture of the latter fry a great shoal of adults, full grown and *ready to spawn*, passed Tellicherry from north to south and yielded a haul of 250 maunds to the fishermen. This shoal was followed at

PLATE I.

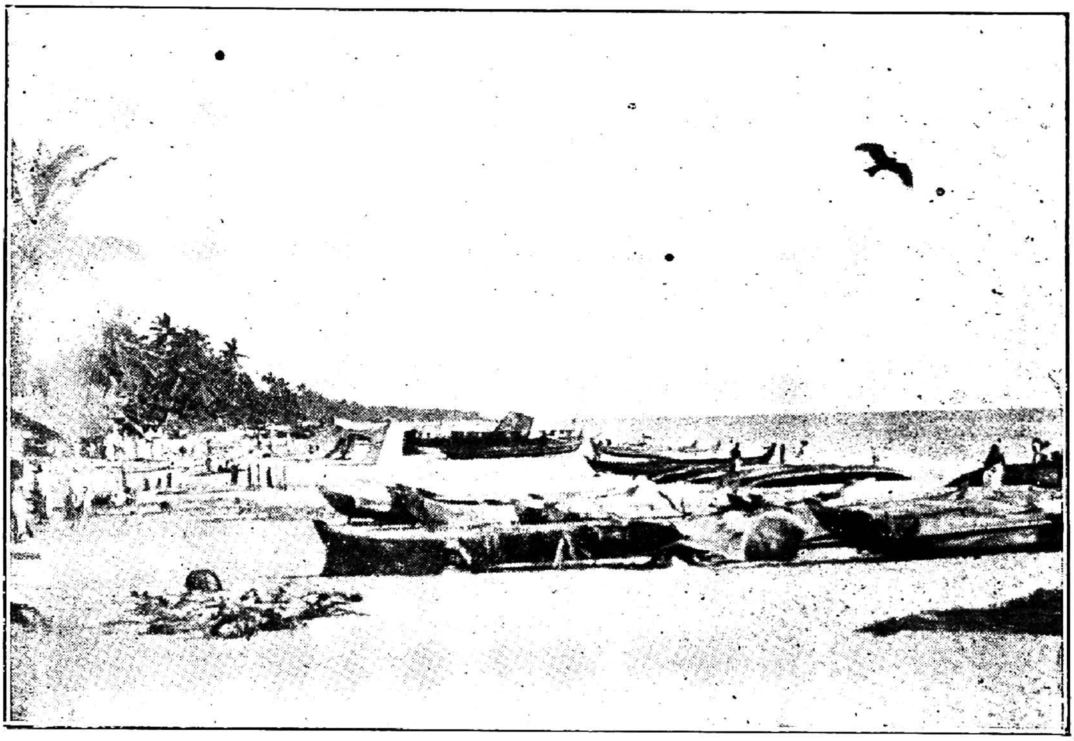


FIG. 3. FISHING CANOES ON THE BEACH, CANNANORE.

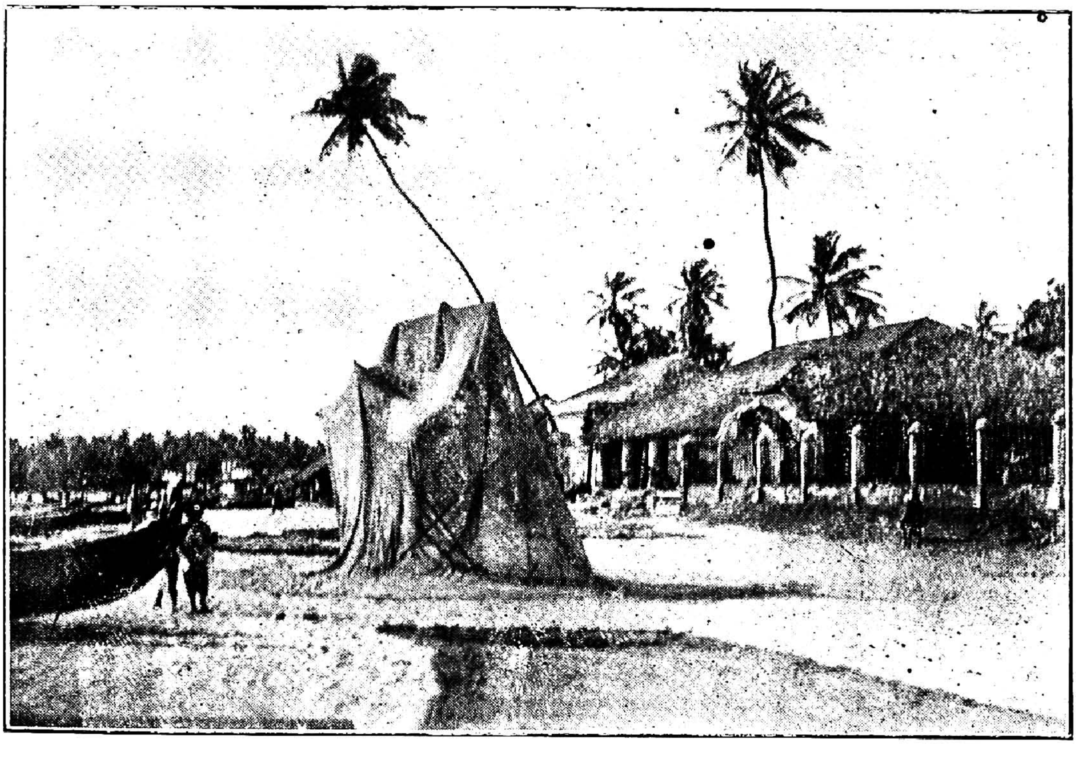


FIG. 4. PERU OR ODAM VALA DRYING, CANNANORE.

[*Photo. J. Hornell.*]

intervals by others with ripe roes right up to the end of August; after that the shoals consisted entirely of spent individuals. The period from the end of June to the end of August may therefore be taken as the spawning season of the oil-sardine on the West Coast; it may be that spawning is a little earlier in the north than in the south, as the shoals appear to arrive off the South Canara coast rather earlier than off Calicut and Cochin, but this is one of the questions requiring more exact observation that has yet been given. After spawning, the nalla-matthi rapidly grow fat and become so oily that there is difficulty in curing them as food and, in consequence, are largely turned into oil and dried for fertilizer. In September these fat-laden sardines begin to be caught and enormous hauls are made in some seasons during the months of October, November and December. In January the fat loading their tissues begins to decrease and by the end of March they are practically free of fat and unfit on this account for canning. Practically the same cycle of events occurs on the East Coast of Ceylon and on those sections of the eastern shore-line of the Madras Presidency (Tuticorin to Cape Comorin and along the Vizagapatam and Ganjám Coasts) frequented by sardines, where shoals appear towards the end of September to disappear in February on the Ceylon Coast and about the end of April on that of Ganjám. The spawning season and dates of arrival and departure of the other sardines *C. fimbriata* (Chala matthi) and *C. lile* agree generally with those of *C. longiceps*, but neither ever attain the extreme fatness of this more important species.

67. Both from what I heard from fishermen and from observations made at sea I believe we have every reason to conclude that during normal seasons, *i.e.*, those during which large catches are made at intervals from July to March, the migration of these sardines, which occurs sooner or later after March, is a comparatively short one. Judging by what little we know of the life-history of other species of sardine in Europe we should infer that, as there, the general movement is probably not one parallel with the coast but one more or less at right angles to it, a migration from shallow water into deep. Many facts support this in the case of the Indian sardine under notice, among others, the observation made during our visits to Calicut inshore fishing grounds at the end of October when we found that, as the result of a cyclonic disturbance in the neighbourhood of Cape Comorin and of a resulting strong swell and current from the South, the shoals of sardines previously abundant at Calicut disappeared entirely and did not return till, at the end of six days, normal weather conditions were re-established.

Again, it is the unanimous statement of fishermen that while they find the shoals come close inshore from the end of September till the middle of February, from about the latter time till the end of the season's fishing the shoals are found farther from the coast, a change which synchronizes with the onset of strong north-westerly winds which blow in February and March causing the sea to be turbid for a considerable distance from the shore. The sardine fishing grounds from July to the end of September are also rather further seawards than those from October to February.

68. It is very significant to note that during the period from October to February practically no current is felt close inshore along the South Canara and Malabar Coast line; the wind at this season is a land breeze so that a band of wonderfully still water, varying from two to three miles in width, skirts the coast under ordinary conditions. In this neritic zone in response to strong sunshine, the semi-stagnant physical condition of the medium and the rich mud bottom, a phenomenally luxuriant growth of diatoms springs up as though by magic, followed by prodigious swarms of tiny crustaceans (copepods, ostracods, phyllopods, etc.) and worms that feed on the diatoms and on one another and in turn become rich food for larger organisms. I am fully convinced that to feed on this apparently inexhaustible banquet and to give their fry a well-fed start in life are the two great reasons that impel our sardines to come close inshore during years of favourable weather conditions. Examination of the stomachs of the fish, comparison of the contents with the nature of the plankton collected by our tow-nets, together with a daily study during five weeks spent at sea on the sardine coast of the coincident presence of sardines and particularly rich aggregations of certain forms of plankton whenever physical conditions conduced to an enormously rich and rapid growth of such organisms, have left no room for doubt in my mind as to the reason for the movement close inshore of sardines during such weather and current conditions as we had in October, November and December 1908.

69. *Food of sardines.*—On the surface of the muddy deposit which forms by far the chief proportion of the sea bottom both in the shallows and up to depths of 30 fathoms everywhere off the Malabar and South Canara coasts, a dense flocculent growth of diatoms springs up whenever and wherever still water conditions prevail; the optimum of such conditions appears to be reached in normal seasons between the end of September and the beginning of February in the warm shallows under the lee of coast, the period in which the skies on the West Coast are

clearest and sunshine strongest, conditions most favourable to the rapid growth of such plant life as diatoms. It is on this flocculent scum of diatoms, a scum that is not always quiescent upon the bottom but is known to rise towards the surface under certain conditions of light and temperature, that I found sardines feeding largely during October, November and December as shown by microscopical examination of the stomach contents of fish caught at this season. Fishermen and the fish-curing yard officers always describe the food of sardines as "mud"; the fish-curing returns continually contain the statement "stomach contents—mud". To the naked eye the contents of the stomach and intestines of every specimen I have examined, appear as a smooth homogeneous stiff greenish-grey mud; broken up in water and examined under a hand lens or low power of the microscope no recognizable constituents can be made out, but when viewed under a $\frac{1}{6}$ or $\frac{1}{8}$ inch objective the mass becomes resolved into a paste of organic debris mixed with large quantities of many species of diatoms. Among the genera represented the most numerous are *Coscinodiscus*, *Navicula* and *Pleurosigma*. Considering the large quantity of unrecognizable debris present, together with such things as decayed fragments of the vascular tissue of plants, it appears to me that much of the feeding of sardines takes place on the bottom, and that they browse upon the flocculent surface of the muddy sea-bottom, in analogous manner to that in which grey mullet may be seen in aquaria cropping the low algal growth and slime that often gather on the sides.

70. Not having yet had an opportunity to visit the West Coast during the first half of the year, I am unable to write with any certainty either of the cause which impels the sardines about April to move away from the localities where they had been abundant during the preceding six months or of that which brings about gradual absorption of fat during the early months of the year. From the fact that in February strong winds from the north-west set in, producing a more turbid condition of the sea along shore and that from this time onwards catches of sardines are made at a greater distance from the shore than from September to February, it appears probable that bottom currents set in with gradually increasing strength dispersing and arresting the growth of that diatom scum in shallow inshore waters which we know from observation is luxuriant during at least the last three months of the year. With such dispersion of the main food supply, sardines probably find their inshore commissariat inadequate to feed their great multitudes with the two-fold result (*a*) that much of the reserve fat in their tissues is used

up, and (*b*) that the shoals break up more or less and pass gradually into deeper water, where although there may not be such an enormous abundance of food as in inshore waters from October to January, a sufficiency may be found under normal conditions. to satisfy the hunger of the disbanded shoals as the sea bottom as far as the depths of 30 to 35 fathoms consists of the same fine mud met with in depths of from 2 to 6 fathoms; there is probably a free growth of diatoms there quite apart from the abundance we find suspended and floating in the water, and on such the sardines probably disperse to feed. This will be a subject for future detailed investigation as will also be the possibility that the sardines may change their dietary at certain seasons and feed freely upon what may be termed mixed plankton instead of confining themselves to diatom scum.

71. This movement from shallow to deep water, from depths of 2 to 6 fathoms close inshore to greater depths up to perhaps the 30 or 35-fathom line, which we have reason to believe occurs in normal years about March or April, may be termed the *minor or normal annual sardine migration*, in contradistinction to that major occasional migration which takes place at irregular intervals of several years, when after several seasons of abundance, sardines forsake their inshore haunts for several consecutive years to reappear suddenly in shoals of immense size.

72. *The occasional disappearance of sardines from inshore fishing grounds* for several years in succession is a fact that greatly hinders and handicaps the development of several important industries, to wit, canning and the manufacture of sardine oil and fertilizer, as capital is shy of investing in a trade where the supply of the raw material is uncertain and widely variable in quantity as well as in price from year to year. To discover where the shoals go in those years when they desert the shallows during the usual fishery season and then, when found, to determine how best they may be captured in quantity, is a task so important, because of the enormous loss entailed by bad seasons upon the fishing community and the industries depending on the sardine fishery, that it may well be esteemed the most urgent and most important problem calling for sustained investigation and intensive study on the West Coast.

73. The present position is one of almost utter ignorance. We have no exact data whatever that will help us except the probability that this major cyclic migration is influenced by causes related to but very much more powerful than those which produce those minor periodic seasonal movements whereof we are beginning to understand the significance. Judging by such

presumed analogy, it may be taken as probable that the virtual disappearance of sardine shoals during one or several consecutive years is due to a certain periodic combination of unfavourable conditions in inshore waters entailing the non-production in sufficient profusion of the diatomaceous growth which constitutes the inshore attraction to these fishes. Possibly these adverse conditions will be found to begin in or be largely influenced by exceptional disturbances of the sea at critical junctures, by exceptional long-shore currents abnormal in power or in direction, or by changes produced in the density of the inshore water either by lack or by superabundance of monsoon floods, more especially at the end of the south-west monsoon when the inner coastal zone ceases to be current-swept and settles into a stillness lasting for several months. It is my strong personal opinion that this last factor will be found to be of supreme importance; even now fishermen hold the belief that there exists a connection between rainfall and the abundance or otherwise of fishes. They express this conviction clearly in their saying "Poor crops ashore, a big harvest at sea." Now on the Malabar Coast an unfavourable season for the agriculturist comes, not from a scarcity of rain but from a superabundance or from an abnormal distribution, the former principally. Poor crops in this district may generally be correlated with excessive rainfall and this, in turn, by lowering the density of inshore water is likely to stimulate diatom growth to increased activity so producing greater food supplies both for the adult sardines and for their fry, thus increasing greatly the attraction which inshore waters have for sardines at certain seasons. It is a natural ground-baiting of the shallows on an immense scale. As a working hypothesis in the investigation of this sardine problem this possibility will be useful; a study of the density of sea-water at different distances from shore at different depths at selected points on the sardine coast, should form an integral section of the work to be undertaken, together with a comparative study of the local rainfall to ascertain if there be any correlation to be established. It will not be possible to carry this on along the whole coast or even at several stations; we shall probably have to be content with observations made at one centrally situated station during the critical time from the middle of August to the beginning of October, a period which includes both that immediately preceding and that coincident with the advent of the shoals in shallow water. During this period an intensive study of the environment and habits of the sardine should be carried on, and of all the biological and physical conditions in any way likely to influence its movements.

74. Detailed analysis from particular view points should also be made of the great mass of statistics entombed in the records of the fish-curing yards; among others I would suggest that the weekly catches of sardines for all years available be tabulated separately in the case of three or four of the principal yards on the West Coast, that a comparative statement be made out showing the date of appearance in quantity during normal seasons of the different species at the selected centres both on the East and West Coasts, and that a similar one be prepared showing the dates they leave the coast on their minor migration to deeper water. Statistics of the total catches of sardines on the West Coast must be inclusive not only of the quantities used for food but also of the very variable surplus turned into fertilizer and oil, without which the figures do not exhibit sufficiently emphatically the enormous fluctuations so frequently characteristic of this fishery. In making out tables the official year beginning 1st April will be most satisfactory as well as convenient, as the sardine season ends about this date; statistics based on calendar years are much less useful in the case of sardines, as large catches are often made after the end of December, which, under this system of tabulation, are wrongly credited to the subsequent season tending to reduce the disparity shown when an unsatisfactory season follows a highly successful one. Pending the preparation of such statistics, I give below a table showing the fluctuations in the catch of sardines (all species) and also for mackerel for the years 1896 to 1907 as indicated by the quantities cured in Government fish yards. Unfortunately it suffers from the defect alluded to above, being made out for calendar years and not for fishing seasons; neither does it take account of the quantities manufactured into fertilizers, defects which will be remedied in future tabulations. As a consequence the sardine fluctuations are less clearly depicted than they are in actuality. The statistics for mackerel indicate annual fluctuations more precisely as it is rare for this fish to be used otherwise than as food; here again the character of successive fisheries will possess more value if the tabulation be concerned with fishing seasons and not calendar years.

75. The enormous drop in catch from the huge totals of 1896–1897, long remembered as the last of a series of abundant seasons, is brought out clearly; a long period of more or less lean years succeeded, lasting till 1907 when the shoals returned once more in enormous abundance. It would be rash to endeavour to draw deductions from the curve shown pending the

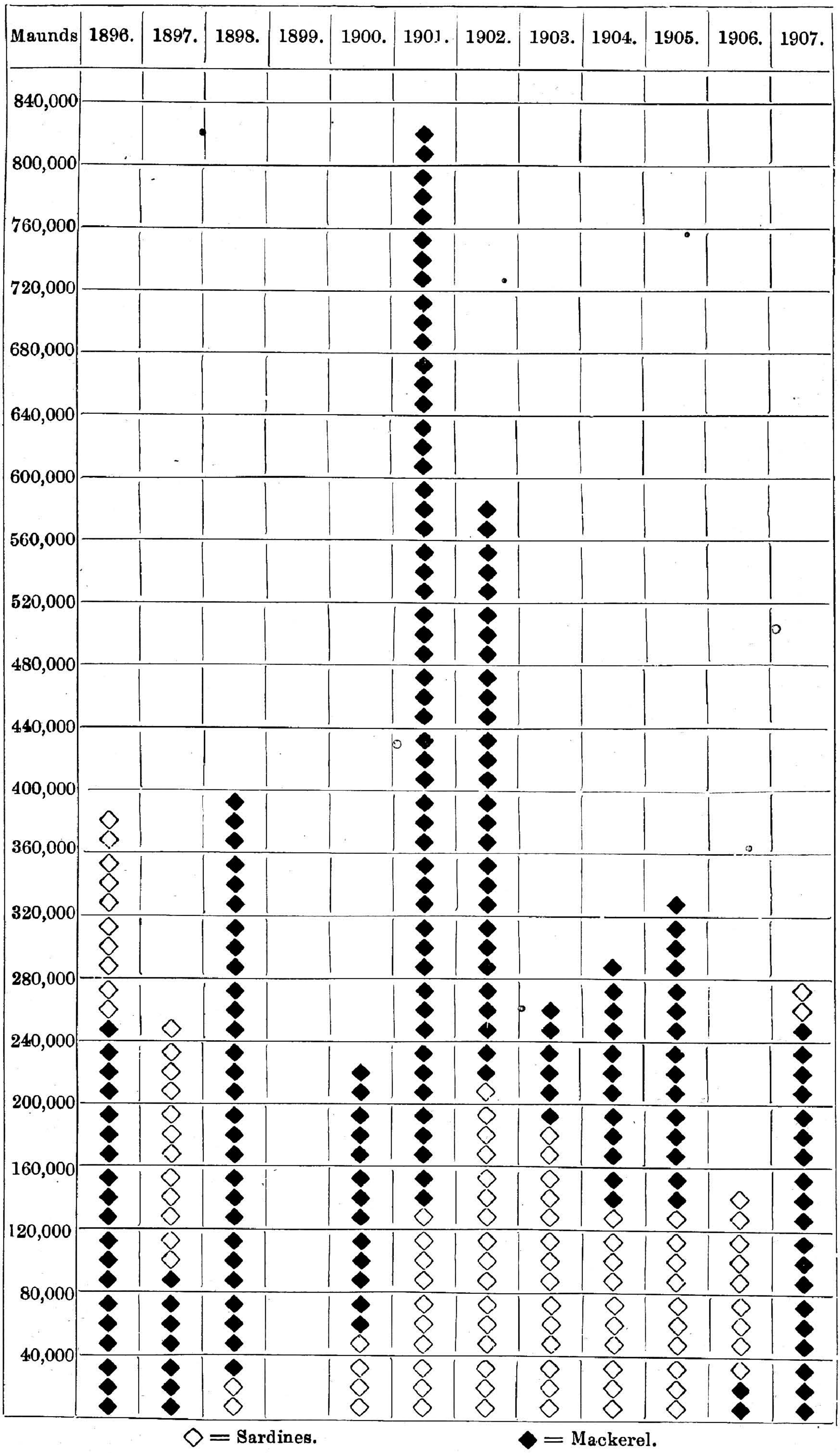
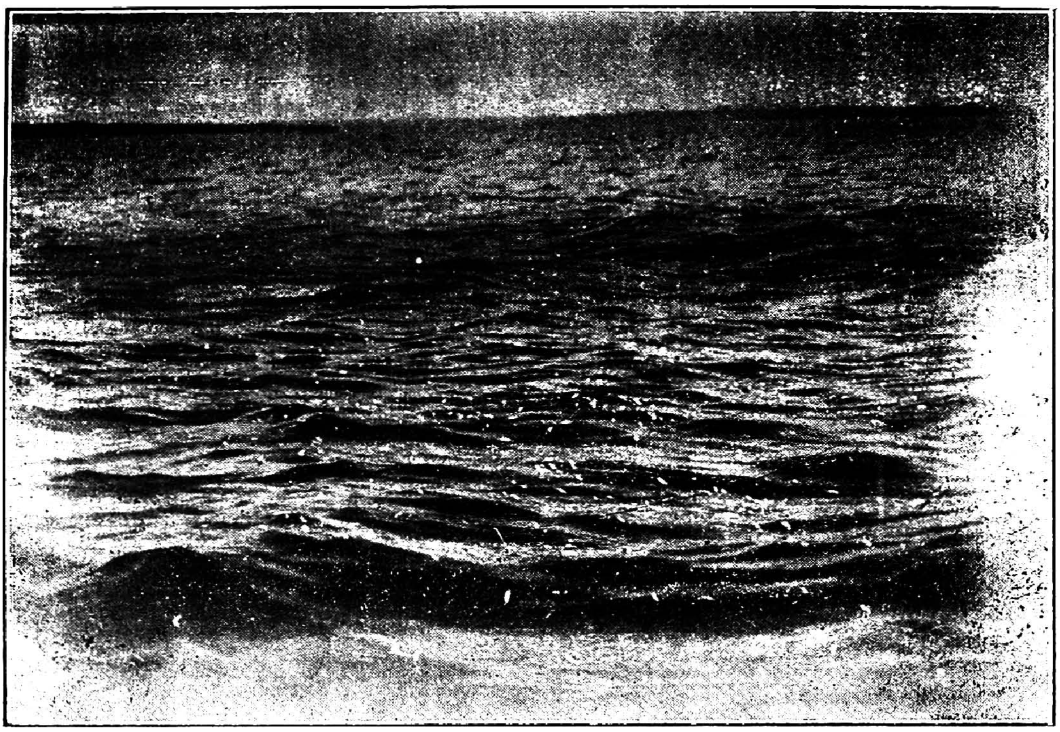
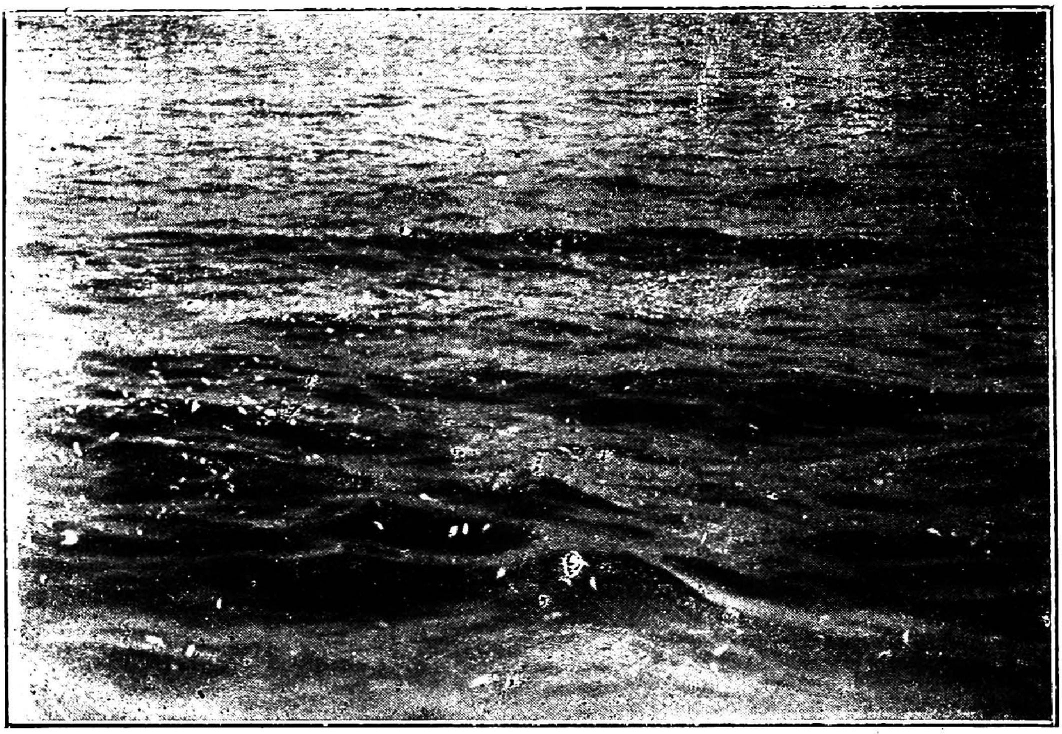


Diagram showing the fluctuations in the quantities of Sardines and Mackerel cured on the West Coast from 1896 to 1907.





FIGS. 5 AND 6. DEAD SARDINES FLOATING IN THE SEA OFF MANGALORE.

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recasting of the returns, but it is worthy of particular attention that whenever a marked diminution occurs in the catch of sardines, that of mackerel takes a great jump upwards, as in 1901; also that the enormously prolific sardine season of 1907 was preceded by the utter failure of the 1906 mackerel fishery, a phenomenon which has its parallel in Cornish waters where a good year for pilchards is generally followed by a poor herring season. In any practical work that may be done in the future in the endeavour to find and fish sardines when they appear to have deserted any particular locality attention should be given to the possibility of attracting sardines to the surface by means of surface bait after the methods employed in the French sardine fisheries.

76. During the period we were on the Malabar and South Canara coasts (October to December 1908), the sardine shoals kept close inshore except during the first week we were there, 24th to 31st October, when they temporarily disappeared. Usually the shoals were from $\frac{3}{4}$ to 1 mile from shore, seldom did we see them beyond this zone, and in no case did we see any considerable shoals further than two miles from land. Porpoises were particularly numerous, often following the shoals into quite shallow water; on several occasions during the second week of December, while the steamer lay in Cochin harbour, sardines entered the backwater in large numbers and on these occasions we invariably observed that they were followed, possibly chased in, by numerous porpoises.

Remarkable mortality among sardines.

77. While steaming from Cannanore to Mangalore on 15th November, when about six miles S.S.W. of the latter port and within three miles of land, numbers of dead sardines were seen floating on the surface. At first they were scattered somewhat sparsely and the water was not distinguishable in colour and appearance from what we had steamed through for hours previously—inshore water greenish-grey and somewhat turbid with suspended matter, chiefly plankton. Very soon a yellowish tint was discernible and this increased, together with an increasing quantity of dead fish till at last the water was a dark yellow, reminding one of the yellow floods of the Yang-tse-kiang; where the water was darkest yellow dead sardines appeared most numerous. Fully half an hour was taken in getting clear of these dead fish, so that they must have covered an area at least $2\frac{1}{2}$ miles in length from north to south.

78. The following day we went trawling northwards from Mangalore. At 11–5 A.M. we shot the trawl in 5 fathoms one mile west of the north boundary pillar of the port and hauled at 1-40 P.M. after having gone $2\frac{1}{2}$ miles northward, gradually shoaling our water, bottom dark grey mud. At the end of the haul we were in $3\frac{3}{4}$ fathoms half a mile from land. All the way during this haul great quantities of the oil-sardine (*C. longiceps*) were passed floating dead on the surface (figs. 5 and 6). Flocks of thousands of gulls whitened the sea all around, gorging at leisure. During most of the time and where the dead sardines were most numerous, the water was a dirty ochreous yellow, dark and thick with suspended matter. Wherever the sardines were most abundant they appeared to have died quite recently; the great majority were still in rigor the body bent in a marked lateral curve. Besides those already dead, many were seen in all stages of sickening, for this patch of dirty yellow-brown sea was full of live sardines not in shoals but in small groups of three and four individuals wandering aimlessly about and in evident distress; every now and again one would rise to the surface gasping, and often had to exert a special effort to descend, others would turn sideways on the surface and for a few moments appear unable to right themselves. Scarcely any other fish were seen except a few small garfish (*Hemiramphus*). Shorewards and southwards of the affected area shoals of sardines were seen in quantity, apparently in normal condition, with many fishing canoes among them, the men using casting nets.

79. The ochreous water, which appeared to have such deadly effect on the sardines, was very low in density, brackish to the taste and registering a specific gravity of 1·021 at a temperature of 83° F.; an oily calm prevailed at the time and no apparent current was noticeable.

80. On hauling the trawl we found it to be full of sardines, size from 5 to 7 inches long; the cod end was full and on weighing the catch we found it to be just over $8\frac{1}{2}$ cwt. A single *Psettodes irumei* (flat-fish) and a few odd fish were also present. The flat-fish and the small miscellaneous fish were alive, but all the sardines were dead. In the appearance of the latter there was nothing apparently abnormal but lifting the opercula, the gills were seen to be pale grey or else dirty brown in colour. The stomachs and intestines showed nothing abnormal to the naked eye and death was recent as no smell of decomposition was apparent and many were in rigor. The fact that the other fish caught were healthy may be accounted for

by the probability that they were caught either before or after we entered the area of foul water.

81. So far as we could judge the area affected was two miles in length from north to south by about a mile in width, its inner margin being about $\frac{3}{4}$ mile from shore ; outside of this area the character of the water improved rapidly and the quantity of floating sardines decreased, but the decrease was marked by a change in the condition of the fish. The further we receded from the foul brownish yellow patch the condition of the fish became worse till at last they consisted largely of headless trunks far gone in putrefaction and giving off a most evil odour. Trawling in this locality disclosed no dead sardines on the bottom.

The mortality must have been enormous and certainly had been proceeding for several days past judging from the advanced stage of decomposition of those on the margin of the area of destruction. Considering that with one small trawl of 15 feet beam we took $8\frac{1}{2}$ cwt. at one haul, part of the time probably not in the fouled area, hundreds of tons of fish must have been destroyed.

82. A haul of plankton was made over the contaminated area at the place where dead sardines were most plentiful. Almost entirely it was found to consist of obscure organic and unrecognizable debris, so fine that the meshes of the tow net became clogged almost immediately, rendering it difficult to collect a satisfactory sample. It had all the appearance of river filth or sewage and contained scarcely any living organisms except a few *Euphausia*-like Schizopods and some fish eggs.

83. The following day, 20th November, we had to leave for Malpe. We left Mangalore anchorage at 7–25 A.M.; at 8 A.M. when $1\frac{1}{2}$ mile northwards of the river mouth and $1\frac{1}{2}$ mile from land we ran into a long stretch of water contaminated with the putrefying remains of sardines. The water was thick in appearance but of an ordinary olive-green turbidity quite different from the ochreous tint of the previous day's experience; apparently healthy fish were abundant, indeed shoals of healthy sardines were about and casting-net fishermen were busy inshore, while some distance northwards of the port boundary pillar, a school of porpoises were pursuing sardines about $\frac{3}{4}$ mile from shore. The stench from off the sea was extremely unpleasant. Specific gravity of the water normal 1026·5 at 82° F.

84. Proceeding north and keeping about the same distance $1\frac{1}{2}$ mile, as before from land, we ran at 9–15 A.M. into an area

where instead of small fragments at intervals, there were large patches, several square yards in extent, with thousands of fish in one continuous sheet of putrefaction—a crust of bacterial scum covering and connecting the bodies. It took 10 minutes steaming at 5½ knots per hour to get clear of this fearful-smelling area, but 5 minutes later an unbearable stench, worse than before, greeted us from still more extensive patches of putrefaction which we passed at intervals for twenty minutes before the worst was over. The largest continuous sheet, a fragment of the Sahara in appearance, was from 60 to 70 yards by some 20 yards wide. The stench was so bad that several of those aboard were either sick or on the verge of being so Not till 10 A.M. when we were off Mulki, two hours from the time of seeing the first dead fish, did we get clear of putrid fragments. They extended for a distance of between 10 and 11 miles parallel with the coast on either side of the steamer which passed up the coast at a distance of about 1½ mile from land. As on the previous day a dead oily calm prevailed, and the water remained fairly wholesome in appearance all the way.

85. From the fact that we saw sardines freshly dead in ochreous looking water to the southward of Mangalore on 15th November, that the next day we saw sardines actually dying in similar water to the northward of the port, and that the succeeding day, 17th November, we passed through a gradation in putrefaction, from freshly dead to putrescent bacterial scum, on our way from Mangalore northwards to Mulki, it would appear as though the source of the mortality lay to the south off the mouth of the Mangalore river and was travelling very slowly northwards with the inshore drift.

86. A somewhat similar strange mortality among fishes was noticed from December 19th to 23rd, 1899, by the officers of the I.M.S. "Investigator" and recorded by Dr. Thurston in "The Sea Fisheries of Malabar and South Canara" (Madras 1900), page 127, as having affected all descriptions of fishes off Kundapur over an area of several square miles. No mention however of the colour of the water over the affected area is made, neither is the specific gravity of the water recorded.

87. From a cursory examination of the plankton collected on 16th November together with the fact of the yellowish tint of the water and its abnormally low density, it seems to me probable that the source of this foul water is to be sought for within the estuaries of the rivers emptying into the sea between Mangalore and Mount Dilli. How it became contaminated is difficult to explain unless it be as Mr. Sherman, Assistant

Commissioner, Salt and Abkári Department, has suggested to account for the death of fishes at Ellatur, near Calicut, that it may arise from the contamination of the backwaters and rivers by the steeping therein of cocoanuts, a process carried on upon the West Coast on an extensive scale. Whatever be the cause it appears that under a condition of unusual quietude of the sea near land it is possible for a large body of water of comparatively low density to remain compact and undissipated for days together although surrounded by water of a considerably higher density. Especially when fouled with a large proportion of very fine and almost slimy organic matter in suspension, possibly accompanied by extractive compounds as in the case when cocoanuts are soaked long in stagnant water, such brackish water can well be understood as likely to prove fatal to fish which enter its mass and there lose their bearings.

Mackerel (*Scomber microlepidotus*, *Rupp.*).

88. This, the *aila* of Malabar, *bangadai* of Canara and *kanangkellati* of the Coromandel coast, ranks next in economic importance after sardines on the West Coast; in many respects the mackerel and sardine fisheries follow parallel courses and are usually synchronous.

The common Indian mackerel is considerably smaller than the English species, running about 5 to the pound; its greatest circumference varies from $4\frac{5}{8}$ to $4\frac{3}{4}$ inches. Its known range, in abundance, on the Indian coasts is wider than that of sardines, for not only is it taken in great quantities all along the west coast of the Presidency and off the shores of Tinnevelly in the south and Vizagapatam and Ganjám in the north on the east side, but it is also common along that central coast line between Madras and the Gódávari where sardines are never caught in quantity.

89. *Seasons.*—The chief fishing season for mackerel on the West Coast is from the end of October or the beginning of November to the middle or end of January when the shoals usually begin to break up and continue to decrease till the beginning of April when they practically disappear. They are however often found in small numbers during other months of the year. On the east coast of Ceylon they appear in November, but December is the month when fishing is at its height. Further north at Madras, Pulinjerikuppam (Pulicat), and Dugarazpatnam, I saw exceedingly large quantities caught towards the end of August 1908, but such great abundance was considered exceptional by the fishermen who said they had not seen them so abundant for a generation and conjectured that they must have

deserted the Malabar coast for some reason. Such however was not the case, for though 1908–1909 has not been an exceptionally good year for mackerel on the West Coast, it has been up to the average and some very heavy catches are recorded, for example, Malpe fish-curing yard was full of this fish when we visited it on 20th November, and we were informed that almost 3,000 maunds or 110 tons had been taken into the yard the day previously, all caught by the great shore seines or rampini nets used there. Generally the season on the Madras Coast is in two sections, August and September, and again from the middle of January to April.

90. On the West Coast, mackerel are found with fully developed roe in June, July and August; the bulk of spawning occurs at the end of July and beginning of August. Dr. Day mentions that he has seen this species at Madras with ripe roe in March.

Present position of the Mackerel industry.

91. At present no effort is made or is possible to fish for mackerel except in shallow inshore waters. The fishermen invariably wait for the shoals to come inshore before making any effort to begin the fishery. In no case during our visit to the West Coast did we see mackerel fishing canoes two miles from land; usually they fished within the limits of from one to one and a quarter mile from shore, while at Malpe where the largest catches seen by us, were made, the principal engine employed is a shore seine. On the East Coast, the industry is in the same undeveloped condition.

92. On the West Coast, the nets in common use, are—

(*a*) the rampini balai, in the north portion of South Canara,

(*b*) the odam or peru vala on the Malabar coast,

(*c*) the patti balai of South Canara which is the same as the aila vala, aila chala vala, or thathu vala of Malabar,

(*d*) casting nets.

93. The first two are forms of seines, the first a true shore seine, the second a very elaborate and effective bag-net seine requiring the services of two large canoes, and having points of resemblance with the purse seine. The aila vala or patti balai is a gilling net, the meshes exactly the size of those employed in Scotch herring nets (2 to $2\frac{1}{8}$ inches). Sometimes it is used at night as a drift net but more usually as an encircling seine to the accompaniment of splashing and shouting to frighten the

fish and cause them to dash upon the net and become meshed; hence the name thathu vala.

This form of fishing is of comparatively recent origin and has not been more than 15 years in use at such centres as Tellicherry, Badagara, and Calicut, and is viewed with great disfavour by the peru vala fishers. Its alleged demerits should receive attention, and the effects of its employment in the centres where most used carefully investigated.

94. Reference to the diagram facing page 100 shows graphically how variable is the catch of mackerel from year to year; how in some years there is absolute dearth and in others enormous abundance. It is very noteworthy that mackerel and sardines are scarcely ever abundant in the same year; a good year for the one is usually coincident with an unsuccessful fishery for the other. What may be the factors at work we do not know; the food and feeding habits of the two when fully known may afford the needed enlightenment. For the present all we can say, from the examination of the stomach contents of mackerel taken within $1\frac{1}{4}$ mile from shore is that this fish during November on the Malabar coast, feeds almost wholly upon those minute crustaceans which at that season constitute so large a bulk of the surface plankton of inshore water. Fragments of copepods and daphniæ form the principal constituents of the stomach contents with a fair number of dinoflagellates (*Ceratium* chiefly) and diatoms. If we compare this with the food of sardines in the same localities and at the same season, which is characterized by an almost complete absence of small crustacea and is made up of diatoms and organic debris, we may infer that whereas the sardine is largely a bottom feeder, the mackerel feeds some distance above the bottom following the shoals of minute crustaceans according as they rise towards the surface or sink some distance below. In this the Indian mackerel agrees in habit with the English species which is considered so essentially a surface swimmer that mackerel drift nets are made only half the depth of herring nets. The sardine may be described as phytoplanktonic, the mackerel as zooplanktonic in feeding.

95. *The prospects of improving the mackerel fishery* seem decidedly good. The present method of prosecuting it is limited to the netting of a very narrow zone of shallow water and a waiting upon Providence to send the shoals close inshore. No effort is made to seek the shoals although there is good reason to believe both from analogy and observation that they move up or down the coast at some seasons and at others migrate towards deeper water. No effort is ever made to follow them when they begin to move away from a particular locality;

indeed we may take it that so long as catamarans and canoes are used exclusively in the mackerel fishery no further development is to be expected. With good boats and drift nets running to one or two miles in length—not the pocket handkerchiefs at present employed—there is every probability that the length of the fishery season and the total of the catch may be very greatly increased. Take, for instance, our experience on the 10th November; on this date no mackerel were being taken on the inshore fishing grounds at Cannanore and the fishermen were lamenting that there was every probability of a bad mackerel season. Yet the same day when we went out trawling off this very port, at 14 miles from land we saw a school of porpoises in pursuit of a large shoal of this same fish, the mackerel leaping out of the water in numbers whenever the porpoises got in upon their phalanx. The same applies to the fishing off Madras. There mackerel are present at two seasons, but the nets used are of very small catching power unless the fish come quite close inshore during perfectly fine weather. If they stay a couple of miles out, or if the weather be anything but calm, no catches of any value are made. Seeing that this mackerel is of a very good size for many curing purposes and highly esteemed among the mass of the people, it would be of the greatest benefit to the consuming public, quite apart from what profit would accrue to the fishing community, that this fishery should be developed further by the employment of larger boats and long fleets of drift nets to *follow* the mackerel upon their migrations and, if need be, to use either nets of special design or ground lines if the fish be found to go to the bottom during certain months as they do in home waters at the close of the autumn fishery.

D.—The distribution of plankton off Malabar and the Laccadives.

96. This was one of the most important subjects for investigation, but the great importance of the issues involved in accurate analysis and tabulation of the results and the very large amount of material collected require that it be made the subject of a separate report and worked up in such detail as is at present impossible on account of lack of time.

97. The collection consists of 80 samples taken on every opportunity during the cruise; it is illustrative not only of the food resources of the inshore waters along the Malabar and South Canara coasts but also of the deeper zones between these coasts and the Laccadive islands, a large number of hauls being also taken around and between these islands. One

result of the work has been to show that the plankton of the latter district is not only very interesting and varied as is already known but is also great in quantity, abundant enough to be attractive to shoaling fish and sometimes comparing very favourably with the average of the shallow waters bathing the mainland.

E.—The principal fishing methods pursued on the Malabar and South Canara coasts.

98. This will be the subject of a separate report. A large amount of material has been collected but as it will depend largely upon drawings and diagrams for proper presentment, the account has to be held over for the present.

F.—An enquiry as to what West Coast ports are suitable as fishing centres if a deep-sea fishery be developed.

99. The facts gleaned anent this enquiry have been incorporated in a separate and wider report dealing with the ports of both coasts of the Madras Presidency. It is unnecessary therefore to write further upon the subject in this place.

G.—Notes on a cruise to the Laccadive Islands to investigate the present condition there of fishing and fish-curing and the potentialities of their marine resources.

100. In view of the fact that the Laccadive Islands possess no export trade in cured fish worth mention, while the neighbouring archipelago of the Maldives counts this their foremost and most important industry, it was decided that as the former islands are within the administrative districts of South Canara and Malabar, it would be desirable to take advantage of the "Margarita's" presence on the West Coast in November 1908 to pay a short visit to a few of the islands nearest the mainland in order to make a preliminary investigation of the fishing industry as at present carried on and to gauge the possibilities of development.

101. We accordingly left Mangalore on a seven days' cruise at 11 A.M. on 25th November, the bunkers full and all available space on deck piled with coal. At the start the wind was westerly and the sea smooth; when 35 miles out a swell from the north was encountered and increased gradually till 9 P.M. when the ship was rolling heavily. This swell coincided with a marked set to the southward which continued from 30 to 60 miles from land; thereafter the set was to the north-west and west-north-west for the rest of the way to Kiltan, the first island of call.

102. Soon after midday on 26th November we anchored off the north end of this reef on rough coral bottom, going ashore as soon as a pilot arrived to steer our gig through the shallow passage leading into the lagoon. Kiltan is a well defined atoll of oval form, the long axis roughly north and south ; the eastern arc, raised a few feet above sea-level, is densely planted with coconut palms bearing weedy and rat-eaten clusters of fruit and forms the "island", while the long western arc is a sea-level break-water of dead coral protected on the seaward edge with a revetment of vigorous living coral, thence dropping abruptly into 1,000 fathoms. The lagoon is shallow, carrying about 3 feet of water over the greater portion, at low water. The bottom is of white coral sand with small and scraggy colonies of living coral, *Porites* and *Madrepora* chiefly, here and there. Compared with the rich lagoon of such a fringing reef as that at Point de Galle, we miss the massive fungus-like fleshy alcyonarians, the rich carpets of zoanthid anemones and the closely packed array of varied corals in the deeper parts. In their place the sandy bottom of the lagoon is littered with great numbers of cylindrical sea cucumbers or holothurians, some of which when dried constitute that valuable Chinese delicacy bêche-de-mer or trepang.

103. On a small scale and in a very primitive manner an industry in bêche-de-mer even now is being carried in Kiltan, where it is known as Kōkā. We were told that the trade was introduced to the attention of the islanders some three years ago by a Cannanore Mappilla, who stayed in the island for some time, the material being collected by his employees—the boys of the island. Of the many species in the lagoon three at least are recognized as of suitable quality for curing, namely, (*a*) Vella kōkā, mottled grey and dirty brown ; (*b*) Karrta kōkā, black in colour ; (*c*) Soganna kōkā of reddish brown colour. The animals are collected both by wading and by spearing from a boat.

104. The process of curing practised is as follows :—Each holothurian is first cut open longitudinally and the viscera removed ; the thick fleshy body-wall remaining is washed in sea-water and subsequently boiled for not less than half an hour. The time when boiling has proceeded far enough is said to be judged by the character of the odour given out. After removal from the boiling pot, the pieces are pinned open by the insertion of short skewers in order to prevent curling, and are next exposed to the full glare of the sun upon a cadjan platform (fig. 7) for fully seven days to dry thoroughly before

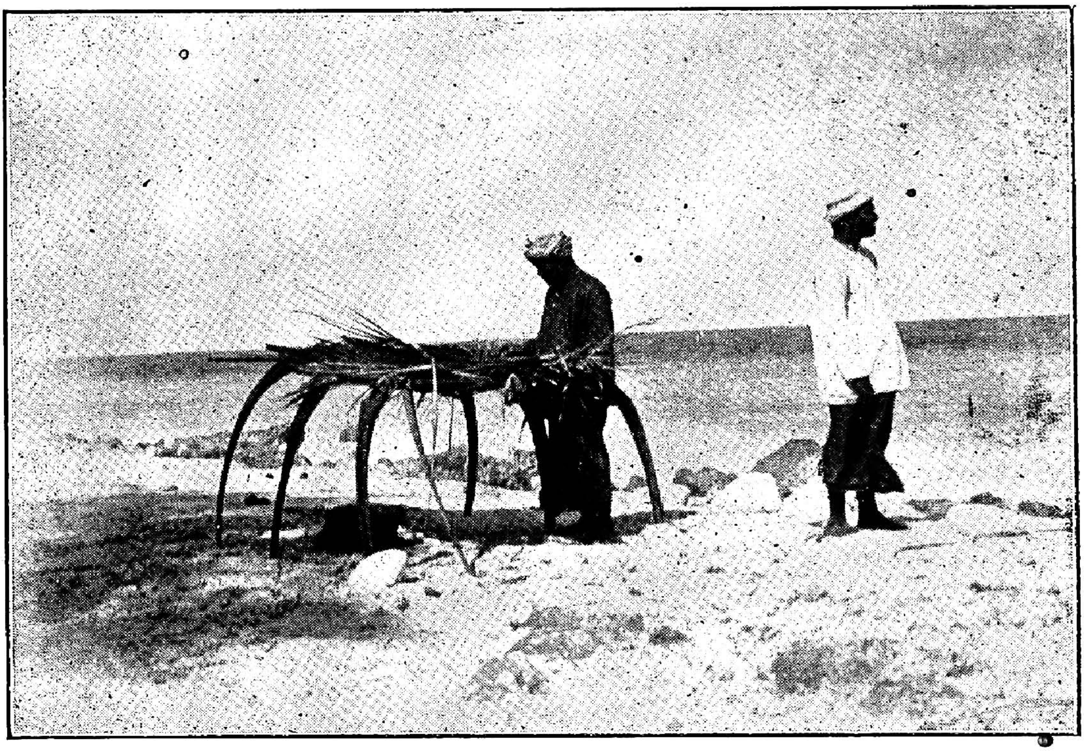


FIG. 7. BÊCHE-DE-MER DRYING PLATFORM, KILTAN ISLAND, LACCADIVES.

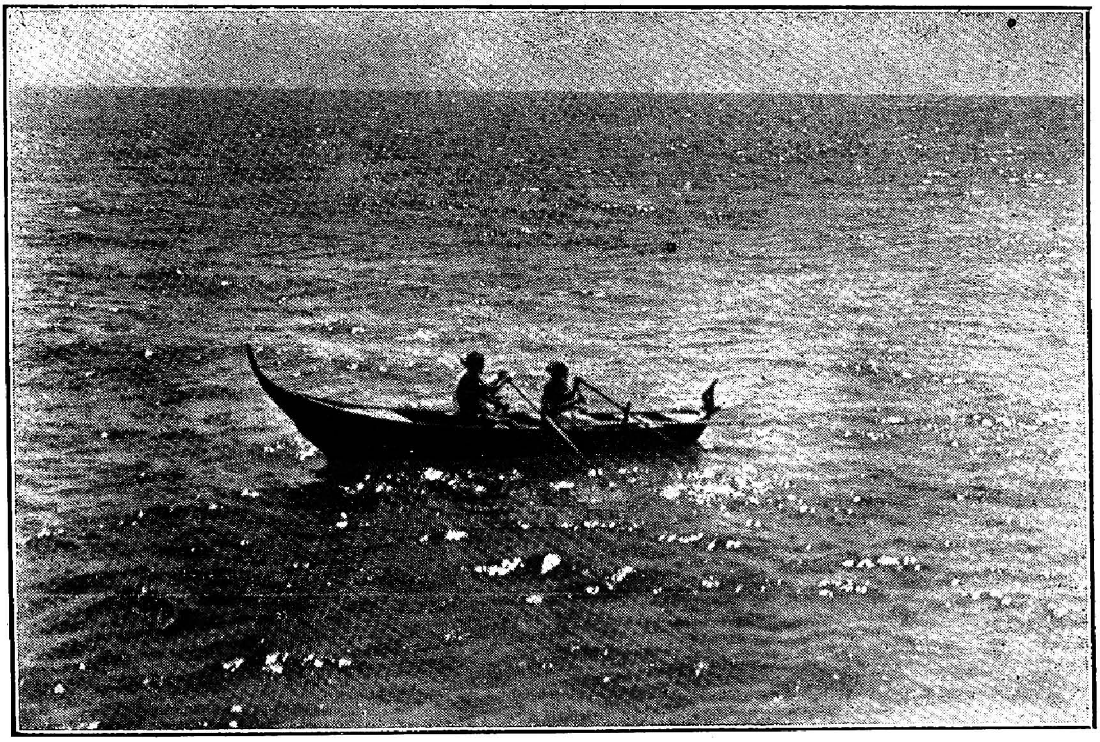


FIG. 10. A LAGOON BOAT, CHETLAT.

[*Photo. J. Hornell.*]

PLATE IV.

FIG. 8.

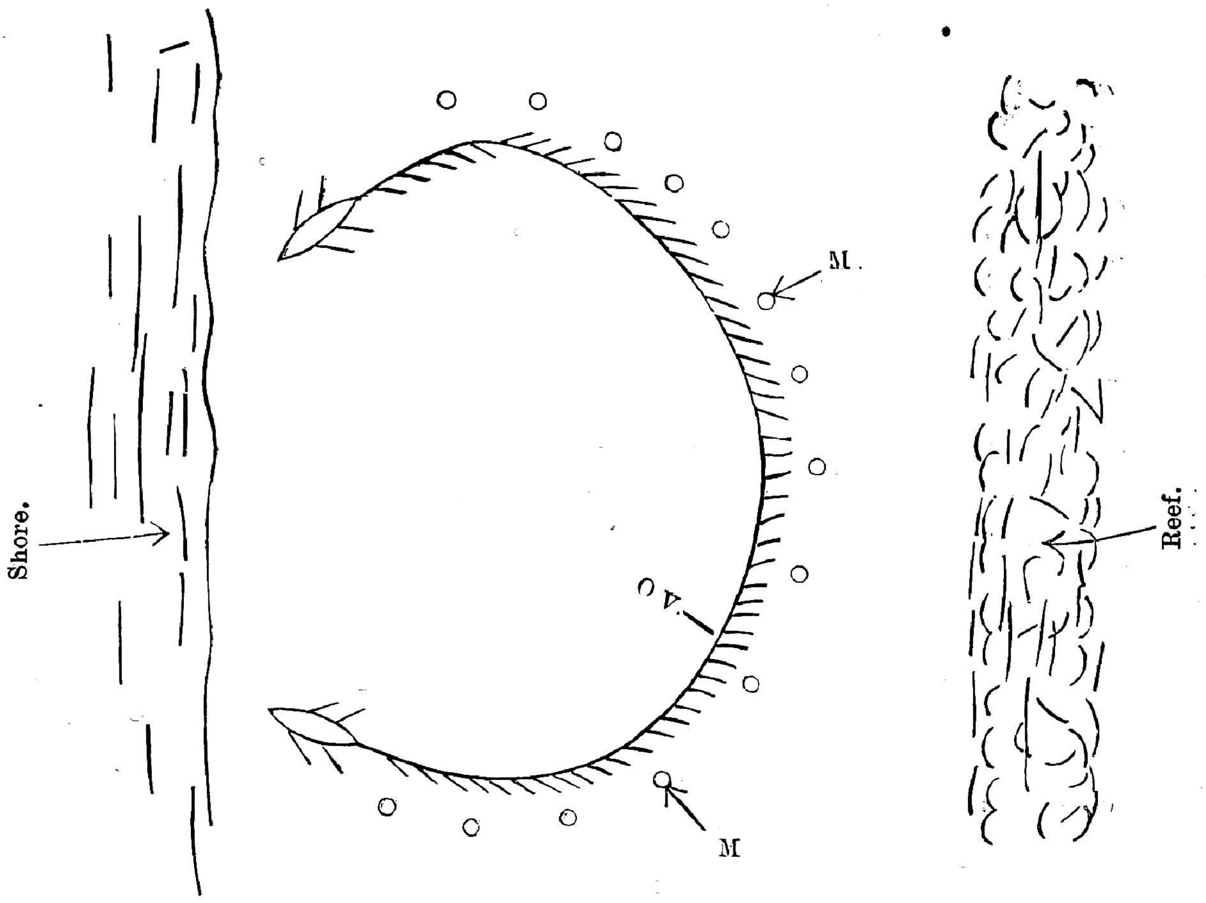
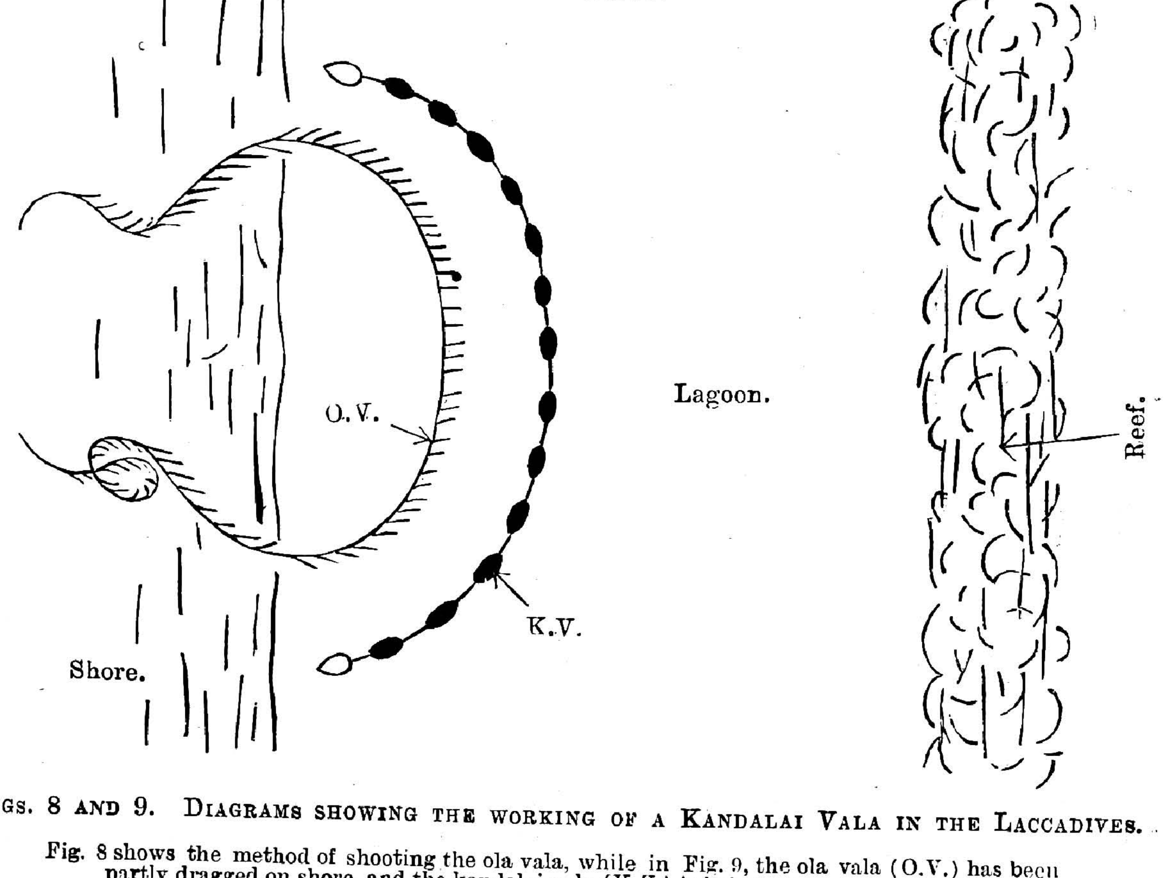


FIG. 9.



FIGS. 8 AND 9. DIAGRAMS SHOWING THE WORKING OF A KANDALAI VALA IN THE LACCADIVES.

Fig. 8 shows the method of shooting the ola vala, while in Fig. 9, the ola vala (O.V.) has been partly dragged on shore, and the kandalai vala (K.V.) is being put round and outside the ola vala. M. are fishermen following the ola vala to shore.

being packed. The price received for the cured product is from Rs. 3 to Rs. 5 per tolam of 28 lb., sold through Mangalore middlemen. None of those refinements are practised which by ensuring good keeping qualities, a fine flavour and a tempting appearance, tend so greatly to enhance prices and make the industry profitable ; of this more will be said on a later page.

105. In the islands at the head of the Gulf of Mannar bêche-de-mer fishermen are aware of the value of oil in stilling ripples on the surface of the water and so permitting of a clear view of objects on the bottom ; when interrogated the Kiltan men stated they never used oil for such a purpose in fishing kōkā, but that they employ a somewhat similar device when they wish to recover objects dropped overboard in the lagoon. Their plan is to chew the kernel of a ripe coconut and to spit the juice on the surface of the water where it spreads as an oily film stilling the ripples. In Kiltan the islanders pay little attention to fishing ; their wants are few and their coconut palms usually sufficient to supply them. The bulk of the fishing done is by hook and line outside the reef on the small submarine plateau where the steamer anchored. The bottom over this area offers the greatest contrast to that of the lagoon —great rounded masses of star and brain corals alternating with huge madrepore bushes giving food and shelter to a host of fishes and crustaceans. The fishing line employed is of white cotton cord, never tanned, and armed with 2 hooks.

106. Within the lagoon, especially during the south-west monsoon, when communication with the world without is suspended, a certain amount of netting is done. Kandalai vala, adi vala and vicha vala are the three forms of nets employed.

107. The last named, a casting net of the simplest construction, is not tanned and is used only from the shore, never from boats as on the Malabar coast. It has no strings, is of unbarked cotton and is furnished with elongated leads strung at short intervals along the margin.

108. The kandalai vala is the largest net used ; it is employed not only in the home lagoon but also very extensively when fishing expeditions are made to the large uninhabited reefs laying far to the westward, *e.g.*, Byramgore, Bitra, Cherbaniani and Perumal Paars. It is a form of shore-seine made of unbarked cotton with $1\frac{1}{4}$ inch meshes in the wings, decreasing to $\frac{7}{8}$ inch in the bunt or centre. The float line is buoyed at short intervals by cylindrical wooden floats threaded on. Usually it is employed in conjunction with a scare line or ola vala, a line to which are tied many narrow strips of coconut leaf. The method of using them is for two skiffs (or two men) carrying the ola vala to proceed side by side some distance

towards the reef; when far enough from shore they separate and return towards the beach, the ola line forming a long semi-circle between them. A crowd of men follow close behind the ola vala to lift it over projecting rocks and to contribute their quota of noise to drive the fish shorewards. The two ends of the ola vala are then taken ashore and drawn well up. When by this means the space enclosed by the ola vala is considerably reduced, two men carry the kandalai vala beyond and outside the ola vala; when half way round they diverge and return to shore laying an enveloping semi-circle of net outside of the ola. The latter is then dragged out and the net pulled to shore as an ordinary seine.

109. The adi vala is another form of small seine used sometimes alone, and sometimes along with the ola vala as above described. It is usually worked in from 4 to 4½ feet of water. It is thinner and of smaller mesh than the kandalai vala. One net measured was 18 fathoms long by 5 feet deep at each end, increasing to 6 feet in the middle. Wooden floats (of paratti wood grown in the island) are put on longitudinally at short intervals and small coral stones are attached along the bottom. Float and ground ropes are of coir. The dead white colour of the net exactly agrees with the hue of the coral sand. The use of this net is almost entirely confined to the home lagoon.

110. Fish spearing is also practised here but the people disclaimed any particular skill in fishing and strongly advised us to visit Chetlat, an island lying to the north of Kiltan, where fishing we were told was vigorously prosecuted. We left Kiltan with considerable regret for the brevity of our visit, a regret which grew the greater when subsequent comparison with other islanders showed up the extreme courtesy and kindness of our first friends.

111. Early on 27th November we hove anchor and proceeded for Chetlat after settling our score for pilotage and other services by the division of half a bag of rice among our creditors who preferred this mode of payment owing to a scarcity of this commodity due to delay in arrival from the mainland of some expected supplies.

112. *Chetlat.*—On arriving off Chetlat we had some difficulty in finding a suitable anchorage as the men from a fishing boat who boarded us at the south end were undecided and contradictory in the advice they tendered. Eventually we anchored near the mouth of the northern of the two passages through the reef and went ashore soon after 2 P.M. in native boats, taking a water glass wherewith to view the bottom. With the aid of this simple instrument I found the

PLATE V.

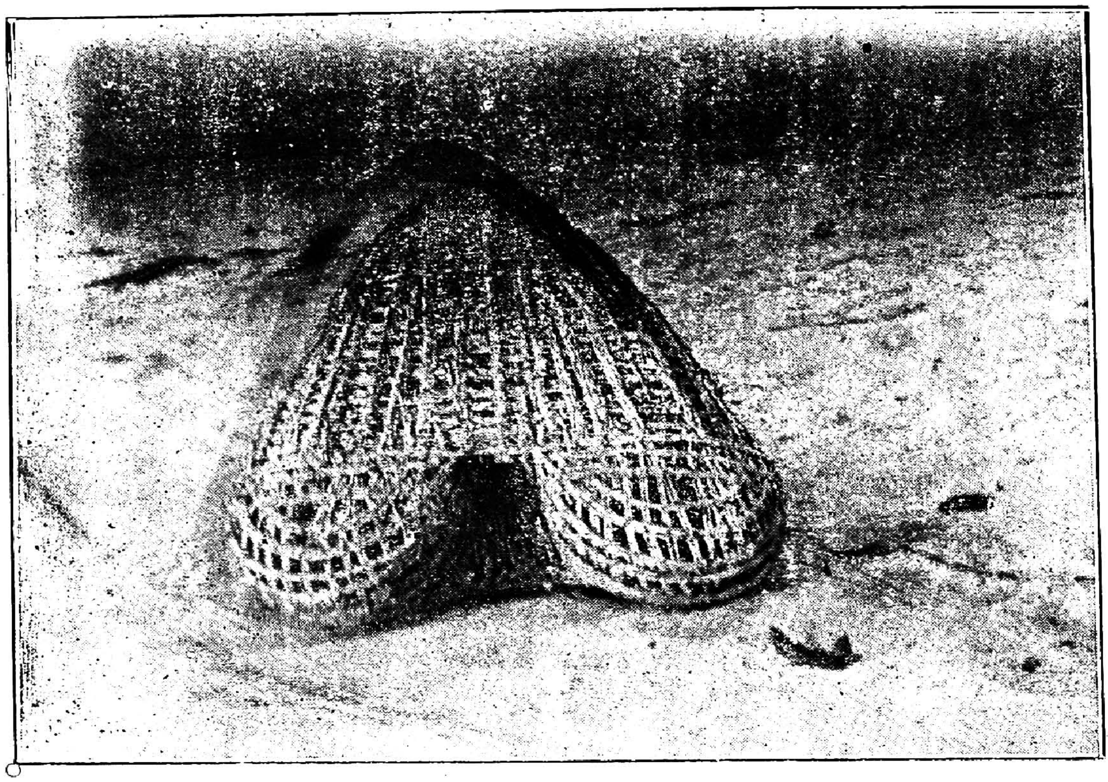


Fig. 11. A Fish-trap, Chetlat.

Fig. 12. A Crowd of Hermit-crabs in shells of the Green-snail (*Turbo argyrostoma* L.), Chetlat Island.

fauna of the lagoon to be much richer and more varied than at Kiltan ; corals were more numerous and of larger proportions while crustaceans and fishes were fairly abundant.

113. The island is almost a facsimile of Kiltan except that the reef which hems in the lagoon on the western side has two boat channels, both broader than the single passage through the Kiltan reef. As a consequence there is a freer run of tide in and out of the lagoon and a greater abundance of food for lagoon-living animals. During the south-west monsoon this free run of tide has its disadvantages as a heavy sea is then felt even within the lagoon, rendering it difficult to use either lines or nets. At that season therefore fishing is restricted to the use of fish traps, of which a number were seen during our visit. They are heart shaped in form with the inlet at the wider end. The framework is of rough wicker, the crossings secured with coir twine ; instead of weighting the trap with stones placed within as is customary with such traps elsewhere, the ends of the bottom ribs are allowed to project several inches and on these are piled a quantity of coral blocks to keep the trap in place (Fig. 11).

114. At Kiltan I had found several shells of two species having commercial value in the mother-of-pearl button trade ; one was *Turbo argyrostoma* L., closely related to the Green-snail of commerce (*Turbo marmoratus*) and the other the Trocas or top-shell (*Trochus niloticus*). On landing I showed these to the Chetlat people who at once professed their ability to obtain plenty. To this end we crossed to the eastern side where they were said to be plentiful ; none were obtained alive, but broken shells of the Green-snail were common enough among the beach drift. Our guides said the tide was not low enough but still promised plenty. On further pressure they led the way to a fringe of bushes behind the beach. I could not understand this move till they turned over some large coral boulders under the bushes, when lo! dozens of hairy lobster-red hermit-crabs, each occupying a Green-snail shell, began scurrying away. Within a few minutes a bucketful was obtained and we might have had a boat-load had we wished. (Fig. 12.) No full-sized shells were found, however, possibly because such would be dwellings too roomy for the comfort of the hermits. Later in the day I found some good-sized mother-of-pearl Trochus, all in damaged condition, at the north end of the island, so it is abundantly clear that both shells live on the reef. To determine whether their size and numbers are sufficient to constitute a minor industry will require further investigation ; the islanders both here and at Ameni said that at the "pars" (Bitra, Cherbaniani, etc.) plenty are to be had.

115. The Chetlat palm groves are less prosperous than those of Kiltan and this forces their owners to devote more attention to fishing. As at Kiltan much of the fishing is done with hook and line, but harpooning is still more in evidence. By the latter means shark, sword-fish, seer and other large fish are caught. As a lure a false bait is shaped from wood in the rude representation of a flying-fish. This is a spindle-shaped dummy, about 12 inches long, painted black and white with a flat wooden projection on either side to mimic wings. The pattern most generally followed consists of narrow white rings set widely apart on a black body. Occasionally conventional eyes are added, and in one case a touch of realism was attempted by substituting longitudinal white bands in place of rings and by endowing the tail with a bilobed termination (Fig. 14*a*). The wood used is teak, the pigments, coal tar for the ground colour, and a mixture of chunam (lime) and resin for the white which is not simply painted on but used as a white filling for deep pattern-grooves cut in the substance of the *poë-mīn* as it is called. The harpoon head is of iron, single barbed, with a socket in the base fitting over an iron pin at the end of a long wooden shaft to which it is attached by a length of coir rope, so that when a fish is struck the barbed head may not be carried away. The poë-mīn (literally "false fish", Malayalam) after being furnished with a white rag to its tail is played on the surface of the sea by means of a short rod and line held in the left hand. In the right the harpoon is poised ready to strike the instant a fish makes a rush for the dummy bait. Sometimes, as we observed at Ameni later in the cruise, a real flying-fish is used as the lure. During our visit sword-fish appeared the principal fish caught by this mode of fishing (see Figs. 18 and 19).

116. Flying-fish are themselves taken in quantity by means of a harpoon or rather by a form of "grains" locally known as chellal, consisting of a bundle of pointed hardwood sticks or prongs arranged and somewhat splayed in two concentric rows tied upon the end of a light pole. The inner row of points are short, the outer long, admirably arranged, and having sufficient play to enable them to grip securely any object that may pass between the prongs. A coir cord of length equal to that of the shaft is tied at the near end, the other end attached by a loop to the wrist of the harpooneer. By day, hook and line are used to catch flying-fish; by night only are they speared, the fish being attracted within range

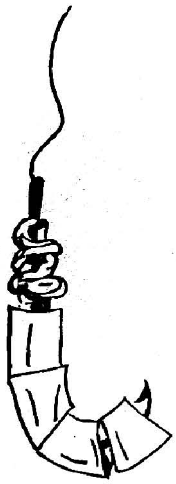


Fig. 20.

PLATE VI.

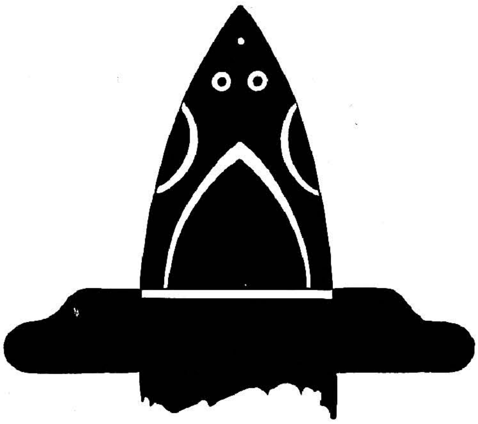


Fig. 15.

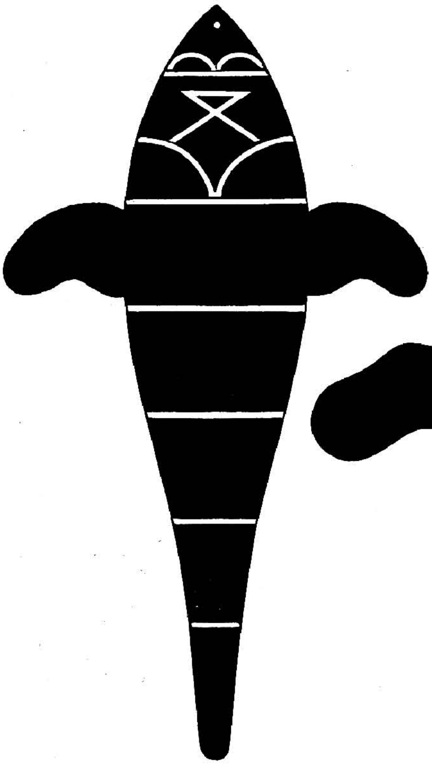


Fig. 13.

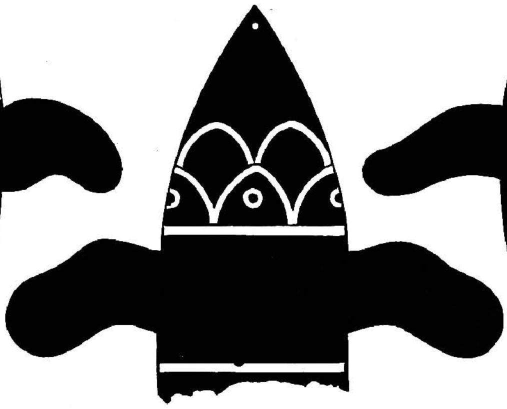


Fig. 16.

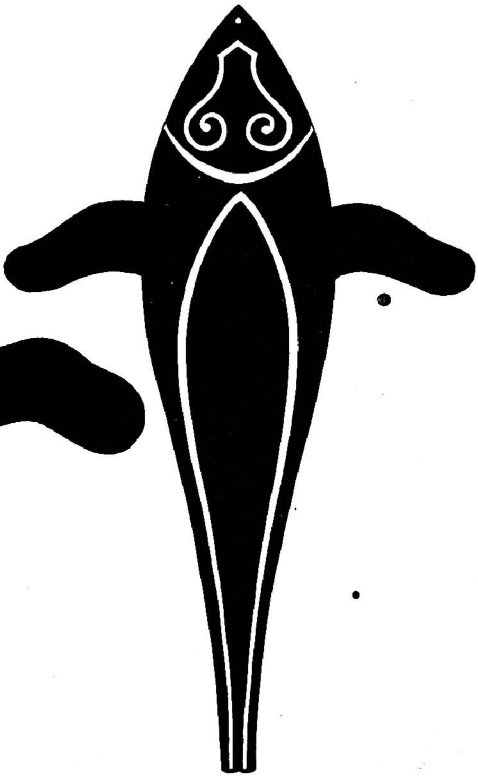


Fig. 14.

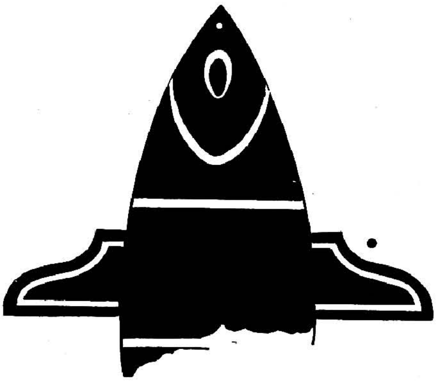


Fig. 17.

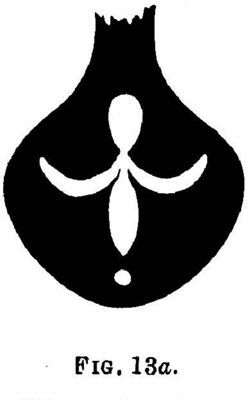


Fig. 13a.

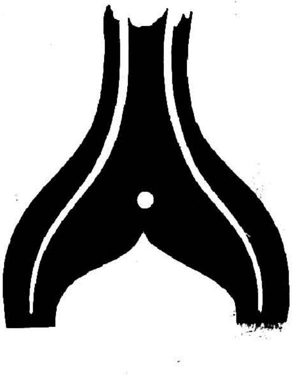


Fig. 14a.

Figs. 13 to 17. Types of ornamentation of Poë-min from Kiltan and Chetlat.
Figs. 13a and 14a are side views of the "tails" of Figs. 13 and 14 respectively.

PLATE VII.

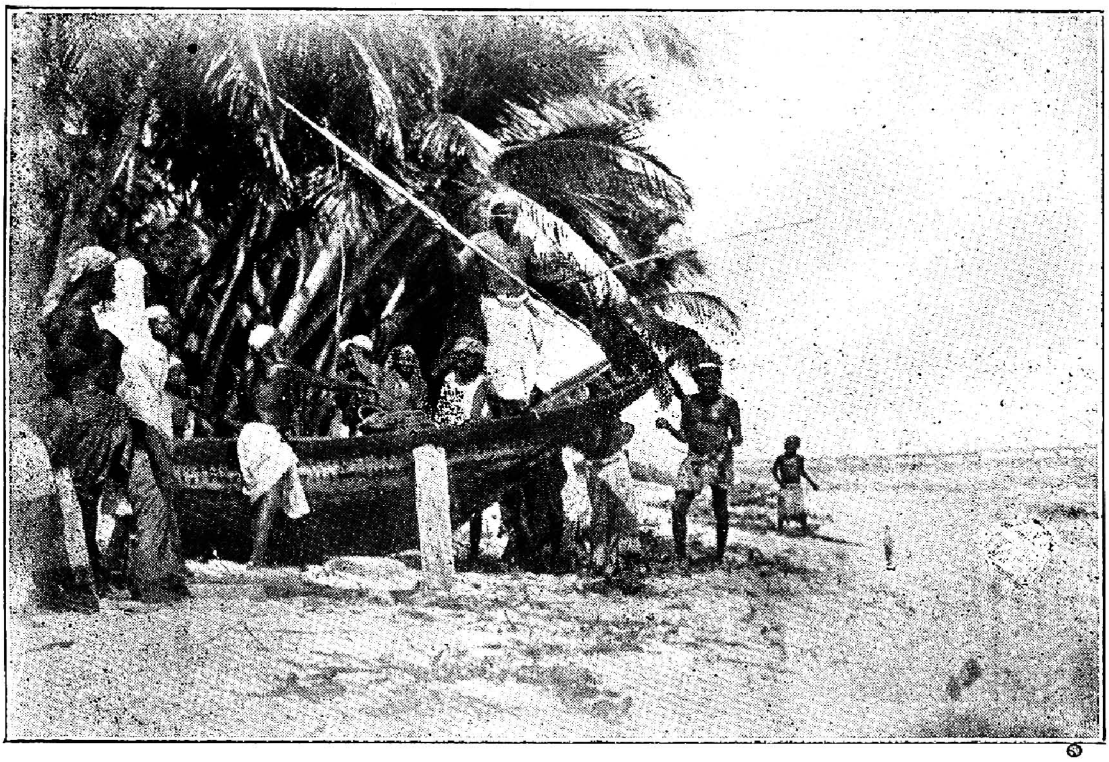


FIG. 18. A DEMONSTRATION AT ANDROTH OF THE WAY A POE-MIN IS PLAYED.

FIG. 19. PLAYING A POE-MIN AT CHETLAT. NOTE THE SINGLE-BARBED HARPOON IN RIGHT HAND.

[*Photo. J. Hornell.*]

of the chellal by torch lights made by burning coconut leaves bound into long bundles. As many as 100 to 150 may be taken in a single night by one boat. The hooks used in day fishing are baited in an ingenious manner appealing jointly to the senses of smell and sight. The abdomen of a small land hermit-crab, a cenobite, pinched off the poor beast's body is thrust on the hook and pushed well up the shank, the remainder of the hook being hidden by four or five cubical pieces of the snowy white flesh of a tender coconut (Fig. 20).

117. The same descriptions of nets are used in the Chetlat lagoon as at Kiltan; fishing in the home lagoon, except at certain seasons, is not of much importance compared with that at the great uninhabited reefs or pars already mentioned. To these, especially to Perumal and Bitra pars, fishing trips are frequently made from Chetlat during the fine weather season, the boats remaining several weeks away at a time. There both lining and netting are carried on, the latter by means of the kandalai vala worked in conjunction with the ola vala. Sharks, rays, sea-perches (*Lutjanus* spp.), bream (*Lethrinus* spp.) and kora (*Sciaena* spp.) are among the chief fishes taken by lines and nets at the pars. I was lucky enough to find a large boat or " Odam " just back from Perumal par the morning we left Chetlat. The party had arrived during the night and had entered the lagoon by moonlight. Partly dried fish lay everywhere; on the bottom, in the rigging and on lines stretched lengthwise from stem to stern. Among the rest I noted fragments of several sharks and rays, notably some of that thorn-backed ray *par excellence*, *Urogymnus asperrimus*, and of a large number of round bony fishes, principally of the genera *Lethrinus*, *Lutjanus*, *Serranus* and *Sciaena*. Round fish were cut longitudinally into connected pairs of narrow fillets, each scored transversely and hung astride a rope or a spar to dry in the sun. No salt is employed except that contained in the sea-water in which they are freely washed before being hung up.

As at Kiltan our stay was all too brief, and as soon as I had made the above hasty inventory I had to hasten aboard the *Margarita* early on the morning of 28th November for the long run to Ameni.

118. On our way there we took several hauls of plankton and coasted along the western side of the long island of Kardamat at which we had no time to halt, interesting as it appeared to be. The lagoon is apparently quite narrow, bounded as in Kiltan and Chetlat by a sea-washed reef on the western side, by the island proper on the eastern. The reef is

a very broad one and a great extent of rock must dry at low tide. This should be a fine collecting ground for green snail and trocas, indeed the Ameni people subsequently stated so definitely.

119. Arriving off Ameni with some daylight to spare, we dredged upon the large bank or submarine plateau from which Ameni rises at the north-eastern extremity. The bottom in 8 to 10 fathoms was found to exhibit considerable diversity, patches of sand alternating with dead coral boulders and masses of live coral, *Porites*, madrepores and astraeids chiefly. A beautiful species of *Spongodes* is fairly common, dark red in colour ornamented on the main axis with conspicuous snow-white spicules; both the coral and the spongodes were full of commensals. Quantities of sedentary tunicates were also found, together with several red algae and a great abundance of crusting nullipore. In its main features this bank is very similar in physical and faunistic features to the rocky banks which the larger species of pearl oysters favour, and there is no physical or other reason I know of why such may not be found on this bank. A diving outfit and a trained diver will however be necessary to test the question as the bottom is too rough for dredging and the water too deep in most places for naked divers. The nets of our dredges were repeatedly torn and the frames bent, and what samples of the bottom we obtained give but a superficial knowledge of the general fauna; molluscs such as oysters are well protected from the dredge by the upstanding masses of live coral and the boulders of that which is dead. Driven to give up dredging by the roughness of the bottom, we proceeded to an anchorage on the south side of Ameni.

120. The next morning we landed at an early hour and found Ameni a thickly-populated island, with evidence everywhere of comparative comfort and prosperity. The houses are substantial, built of squared coral blocks; working goldsmiths from Malabar were seen making gold jewellery, and the greater part of the south coast was occupied by closely-set boat-sheds reared on stone columns. Boat-building was much in evidence, an industry the islanders should be proud of. Nowhere have I ever seen greater skill, patience, and ingenuity in such work; the lines of the boats are of the utmost beauty and the workmanship rather that of the cabinet-maker than of the shipwright. I doubt if the equal of these boats is to be met anywhere else in the fishing world. And these islanders do not stop at giving fine lines, beautiful and sound proportions, and

FIG. 21. A MOSQUE IN AMENI.

FIG. 22. LACCADIVE BOATS, ANDROTH LAGOON.

[*Photo. J. Hornell.*

PLATE IX.

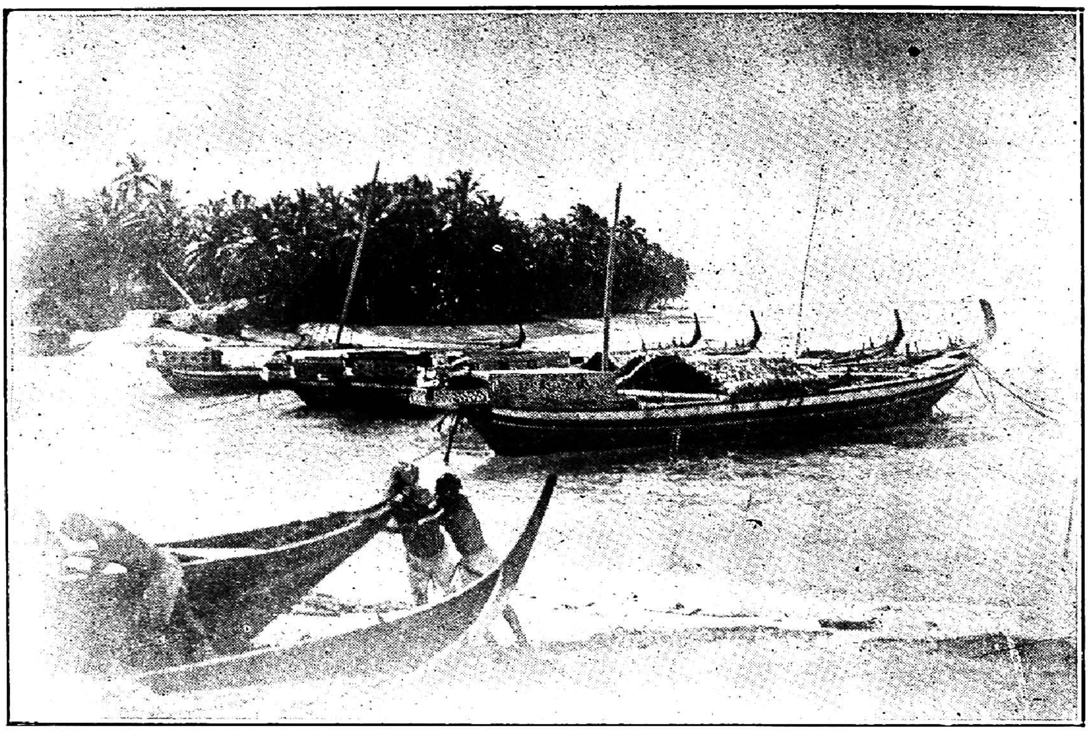


FIG. 23. LACCADIVE BOATS, ANDROTH LAGOON.

FIG. 24. INSIDE THE LAGOON, CHETLAT.

[*Photo. J. Hornell.*]

the best of workmanship to the hull ; they must needs ornament it, which they do with equal success to that characterising the rest of their work. Indeed there is a distinct and well marked sense of the artistic developed in these islanders ; beautiful and often most intricate geometrical patterns in black and white adorn their boats and often their house doors, while their grave-stones, made from a dense, fine grained coral sandstone quarried on the beach, bear further witness, many being exquisitely sculptured and bearing inscriptions in beautifully chiselled Arabic lettering. The accompanying figure No. 22 show some of the patterns used to decorate the poops of their boats. I should mention that these designs are drawn freehand and are not stencils.

121. Fishing is not pursued vigorously, although all the methods operated at Chetlat and Kiltan are known and in use here. Lining on the great bank to the south-west (on which we dredged the day previously) is the chief source of their fish-supply. Mainly this consists of teleost species characteristic of hard bottom *Lethrinus*, *Lutjanus*, *Serranus*, etc., which may appropriately be called "rock-fishes." Sharks and rays are also taken on the bank. All these are taken by hook and line during the day. At night lights are frequently used to attract fish to the neighbourhood of the hooks ; harpooning is also employed when the fish attracted are of large size.

Sword-fish, sharks, plough-fish (*Rhinobatidæ*), large rays, turtle, large seer and bonito are all taken by harpoons during the day. The chellal or "grains" is employed both to catch flying-fish and ribbon-fish (*Trichiurus savala*) at night, attracted round the boats by the light of torches.

122. Sometimes fishing parties go to Bitra and the other great parts, but as everybody is busy with the coconut harvest and the preparation of copra for two to three months of the fine weather season, it may be readily understood that in this island where every yard of land is given over to the coconut, the fishing resources of the sea around the island are largely neglected ; indeed dried mackerel and sardines are actually imported from Mangalore, as it pays better, or is a less laborious calling, to make copra than to catch fish. This seems a great pity for fish are to be had in plenty round the island ; we saw numbers when at anchor here and plenty of rock-fishes (*Lutjanus gibbus* and others) and of file-fishes (*Balistes*) were taken by the crew by means of hook and line.

123. Bonito is said to be plentiful at times, and I extracted an entire one, recently swallowed, from the stomach of a sword

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fish that had been harpooned. The Ameni fishermen say, however, that they don't catch many as the bonito, being a surface fish, will not take the bait on the lines they use for bottom fish and, save harpooning, they do not know any other device for catching this fish !

124. The plankton collected off Ameni was particularly abundant, ranging from 50 c.c. to 135 c.c. in volume for a fifteen minutes haul on the surface. Shoals of schizopods, copepods, and sagittae were characteristic and so abundant as to make this locality an excellent feeding place for small fishes. The quantity taken per haul was much greater than either at Chetlat or Kiltan and is probably due to the large extent of shallow water south-west of the island.

125. On 30th November we left for Androth at 5-30 A.M. experiencing an adverse current running to the west-north-west on the way, strength about $\frac{3}{4}$ knot per hour ; it was 5 P.M. before we anchored abreast the landing place which is near the western end on the north side of the island. As soon as possible we went ashore, and found that a deep channel had recently been blasted through the fringing reef making this the easiest and safest landing we had used ; vessels drawing 10 feet may anchor close in. There is no true lagoon at Androth, the fringing reef being uneven and much interrupted in places and usually very close to shore. While we were ashore we were fortunate enough to see some night-fishing boats prepare and leave for the fishing grounds. The men were going lining and harpooning, and we thus had an opportunity to make an inventory of their gear. It consisted of—

(*a*) four white cotton lines each with one large hook attached by two sections of wire,

(*b*) a harpoon of the usual form,

(*c*) twenty-five bundles of coconut leaves, each bound round tightly at intervals to form a rude torch,

(*d*) a large number of small coral stones,

(*e*) a bundle of fine coconut leaf fibre.

The torches are used to make flares to attract fish round the boat while the stones are intended to carry the hook quickly to the bottom. Should large fish be attracted by the light, then the harpoon is employed.

126. The next day the various descriptions of nets and fishing devices used in the island were brought together for

my inspection by the headman of the island. These consist of—

(*a*) the vicha vala or casting net,

(*b*) koru vala used in conjunction with scare lines or ola vala,

(*c*) fish-traps of two sizes,

(*d*) harpoons and Poë-min for large fishes,

(*e*) the Chellal or "grains" for catching flying-fish,

(*f*) hooks and lines of different sizes, worked and fitted after the fashion of the "paternosters" of home fishing.

127. The vicha vala used in Androth is made of two ply cotton with large mesh ($2\frac{1}{4}$ inch) armed around the margin with beautifully formed crescent-shaped lead sinkers threaded in three places.

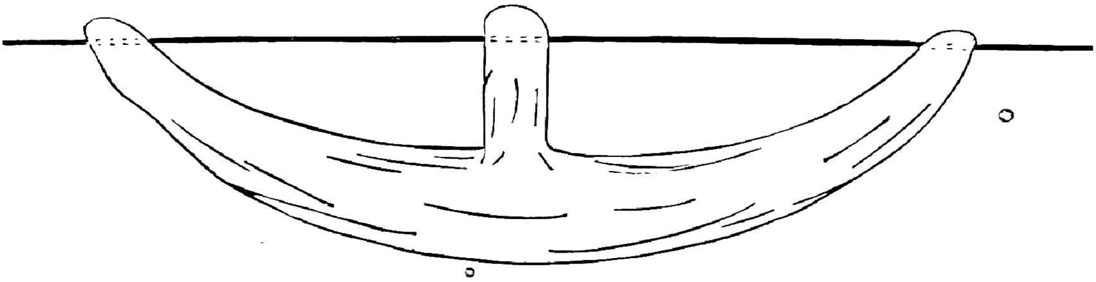

Fig. 25.

Lead sinker of vicha vala. Actual size.

The net is 2 fathoms long (radius) when stretched out. It is used only from the shore or from the reef; on the evening of our arrival we saw a number of men using it as they waded along the inner margin of the reef. No closing cords are used.

128. The koru vala is a fine-meshed cotton net ($\frac{5}{8}$ inch mesh) almost square, being 2 fathoms long by the same deep. The head rope carries 13 wooden floats strung on, while through the meshes of each end a running cord is arranged with a loop at each extremity. When being prepared for use the depth of each end is reduced to half by means of the running cords, the surplus length of cord being secured at the middle by a temporary knot. Four men are required to operate it, one at each end and two to swing in the two scare lines. Each of the men holding the net slips the upper loop of the running cord of his end over one wrist, with the other hand holding the lower loop and one end of an ola scare-line. Two of these are used, one man to each free end. As soon as the net is set these latter men swing in from each side upon the net shaking the olas the while to drive the fish into the net. The koru vala appears to be a primitive form of the siru valai of Pulicat Lake.

129. *Hooks and Lines.*—Five principal sizes are used as follows :—

(1) The largest hook is made of quarter inch iron rod, the bend two inches across. It has a long shank, about 10 inches in length, attached to a stout line by an iron rod joint of equal length. This is employed chiefly for sharks ; the bait used is an entire flying-fish. No sinker is employed, and the depth to which the bait is let down is given as from 10 to 12 fathoms.

(2) The second largest fishing line has a hook six inches long by $1\frac{1}{2}$ inch across the bend, attached to a cotton line by two long joints of twisted brass wire. The bait used consists of fragments of flying-fish.

(3) The third-sized line is armed with two hooks and a sinker arranged in a simple paternoster rig. Fig. 25 depicts the method. The sinker, a piece of coral stone, is tied on between the hooks by a long thread drawn from a young coconut leaf. The bait is a piece of cuttlefish put on high up the hook followed by pieces of flying-fish flesh. The stone sinker is tied on in such a manner as to break away as soon as a fish is struck and the line begins to be hauled up. Rock-fishes are the chief fish caught by this rig.

Fig. 26. An Androth "paternoster."

(4) The fourth sized line is rigged in a similar manner with two hooks but in this case a stone sinker is not tied on ; it is simply hitched on the lower hook to carry it to the bottom and then shaken off by a gentle jerk. As weathered coral stones usually have pits and hollows in their surface it is easy to select such as can be hitched lightly upon hooks. (Fig. 26.)

(5) The smallest hook-line used is armed with but one hook and is baited with the abdomen of hermit crab and cubes of tender coconut flesh. No sinker is attached as this gear is used only in fishing for flying-fish. (Fig. 20.)

Fig. 27. 4th sized hook Androth. Actual size.

130. The Androth men are greater fishers than those of Ameni, probably because they are less well off by land.

Certainly they have developed lining pretty considerably. As a consequence of this activity fish-curing is more in evidence here (though that is little enough) than elsewhere. Shark, rays, and other big fish are sometimes cured by being cut into fillets, washed in salt water and strung up to dry in the sun. Drying is complete in from four to five days. From the end of July to the end of September this curing is said to go on as this is the season when these fish approach the island.

131. Seer (*Cybium* spp.) is also caught at times in quantity by harpooning, and it is most interesting to note that the Androth islanders cure seer very much in the way the Maldivians and Japanese cure bonito, obtaining a product very similar to that "Maldive fish" so highly esteemed by the Sinhalese. The way in which seer is prepared in as follows:—After heading and gutting, the flesh is cut into small pieces of about three inches by one and half inch, washed in salt water, and 8 to 10 pieces strung on a cord. These are dipped into boiling water for five minutes and then, after a short draining and drying, are placed upon a leaf platform raised two feet from the ground. Under this a fire of coconut husks or leaf stalks is lit and kept going all night if the boiling took place in the afternoon; if the operations begin in the morning then they complete the smoking in three to four hours. The smoked product is next put in the sun upon cadjan mats and left to dry thoroughly during three to four days. After this it will keep for months in good condition. At present this product is made only for private consumption, but in view of the excellence of the product and the high esteem in which similarly cured fish is held in Ceylon, Sumatra, and Japan, there is every reason why the Laccadive Islaners should be encouraged to extend and improve this cure in order that the product may become an important article of export as *mas-mīn* is in the Maldives. It is also a cure that might be introduced on the mainland with great advantage wherever bonito and seer are taken in quantity, for the product has many good qualities and commands a high price when decently prepared. Very probably the cure may with advantage be applied to other fish; indeed in Androth we were told that flying-fishes are cured in the same general way, the chief difference being that after they are headed and split they are dipped by the tail for a short time in boiling water instead of being cut up and stringed for boiling, and are smoked flesh side down at first. Rays and *Rhinobatis* are also treated in the same way as seer but are said not to go through the smoking process. Smoked seer is called *kachcha min* in the islands.

132. The flying-fish season was at its height during our visit; we saw over twenty boats which had been fishing with hook and line return from fishing at 3 P.M. on the day we lay off the island. The catches, however, were very poor, not exceeding a dozen in any of the boats that came alongside the steamer. I explained the Negapatam method of luring flying-fish to the boat by a bunch of leaves set adrift at the end of a 200-fathom rope; none of the men had ever heard of such a method of fishing and I fear they considered it to be a "traveller's tale," although they promised to make a trial of it.

133. Harpooning for seer, shark, and sword-fish is carried on in the usual island way, using a wooden *poë-min* as the lure. Those we saw were characteristically ringed with narrow white bands and had eyes of conventional form on the under as well as the upper side of the head. The usual white rag hung from the tail. They showed signs of more frequent use than those we saw in the other islands and on the whole the Androth fishermen seemed more enterprising than those of the other islands.

134. *Bêche-de-mer.*—Considerable quantities are available in the shallows, but the elders of the island are strongly opposed to any development of this industry from religious or rather superstitious reasons. A venerated mullah now deceased had fulminated against any traffic in such scaleless inhabitants of the sea and banned with the threat of misfortune any who should take it up, a prophecy which, we were told, came duly true in several instances. Hence although the people admit that the trade can be made to give a good return, they will have nothing to do with it.

135. *Dredging on Androth bank.*—Northward of the island a shallow submarine plateau extends several miles; to this we devoted the morning of 1st December. The first haul was in $16\frac{1}{2}$ fathoms, three miles north of Androth landing place. The bottom was found to be very rich in coral of many species; as many as eleven different kinds were brought up at one time. Tunicates, chiefly crimson Leptoclinids and a Styela, were numerous, with a few small sponges, hydroids and polyzoa, and a number of worm and crustacean messmates. Next we tried several hauls in $11\frac{1}{2}$ fathoms one mile to the eastward; the bottom proved identical, strong growth of living corals damaging the dredge every time it went down. From this place we moved still further eastward gradually shallowing our water till we came into 10 fathoms, north-north-east of the east

end of the island. For most of the way the bottom consisted of coral-clothed ground as before, but when we came to 10 and $10\frac{1}{2}$ fathoms extensive patches of white coral sand were encountered interspersed with patches of live corals. The scarcity of algæ other than nullipore was most marked, otherwise the bank appeared excellent as a line-fishing ground as indeed the islanders had already told us. Very probably pearl oysters may also be found, and indeed we did catch some vague hints in the island that such had been found; nothing definite was elicited however, and this question must await the employment of trained divers before it can be determined. Our time limit for the cruise had now all but expired, so at 4–15 P.M. on 1st December we reluctantly bade adieu to these islands of peace and content and set out on our return to Calicut where we arrived the next afternoon.

136. The conclusions at which I have arrived in regard to the present condition of the fishing industry in the Laccadive Archipelago and the possibilities of development may be summed up briefly as follows:—

(*a*) Although there is ample evidence that valuable food fishes abound in the Laccadive sea, the extent to which the industries of sea-fishing and fish-curing are carried is extremely limited; no serious attempt has yet been made by the people of any of the islands we visited to exploit adequately any section of the resources of their waters or their reefs. To a great extent this is a consequence of the extreme isolation in which these people live; they have few opportunities to profit by the larger experience of the outside world and as a consequence they are ignorant of many of the principal methods of sea-fishing practised elsewhere. Long lining and drift netting are wholly unknown to them, neither are they aware of the special fishing devices employed on the neighbouring Indian coasts to catch such species as the seer and the flying-fish. Thrown on their own resources they have developed several fishing devices which necessitate great individual skill but seldom give returns adequate to the exertions put forth. Judging from the skill displayed in this and in their boat building and by the excellent sailors they make, the islanders should prove apt pupils were new fishing and curing methods to be introduced to their notice and the value of the innovations demonstrated. With fishing carried on by more effective means the material benefit that would result and the new interests aroused, would make greatly for the prosperity of the inhabitants, who under present conditions depend for their living almost entirely upon their coconut crop and suffer considerable hardships whenever that harvest is

scanty. With increased catches of fish and the creation of an export trade in the cured product, the well-being of the islanders would improve materially and the stress of increasing population would be met more easily.

137. (*b*) The lines upon which fishery investigation and experiment are called for and appear most promising are as under :—

(1) The thorough trial of such new fishing methods as seem likely to be of special service under the local conditions prevailing in the Laccadives, for example, drift nets for the capture of sharks, rays, seer, bonito, etc., floating long lines or trots for the same purpose, while for flying-fish the Negapatam screw-pine lure should be tried. The creation of a bonito fishery on similar lines to that so successfully carried on in the neighbouring Maldives should receive special attention, especially as the main reason why there is none at present in the Laccadives is stated to be a scarcity of the bait necessary rather than of the fish to be caught. The removal of this impediment to the conduct of what *in the Maldives is the principal industry of the islanders* is a subject meriting special and prolonged investigation; if successful, and if we judge by what holds good in the Maldives, the life of the islanders would be revolutionized and their resources more than doubled.

(2) Improvement in the methods of fish-curing requires attention the moment we contemplate an extension of the catching power of the islanders. In the smoking of seer and flying-fish as practised at Androth, we have fortunately a good foundation to work upon ; in details the method may be considerably improved at the cost of little trouble to the curers. This cure has the great advantage that no market has to be created for the product ; Ceylon and the Dutch Indies will consume all that may become available, to say nothing of India where a taste for Maldive fish (más-mín) is certainly spreading. Dried flying-fish should also become an export of considerable value if this fishery be developed. When a coastalport like Negapatam is able to develop a deep-sea fishery, much more should the Laccadives where the "black-water" actually washes their shores.

Again, sound methods of salting aboard ship must be taught the islanders, and provision made to supply the salt requisite for the purpose, if the fishery resources of the great "Pars" are to be exploited properly, in view of the fact that all fish caught there must be cured aboard the boats as no dry land for a fishery camp is usually available on these fishing grounds.

(3) *Mother-of-pearl.*—Apart from the possibility that pearl oysters exist in paying quantities on the banks adjoining Androth, Ameni and other islands and at the various "pars," Bitra, Cherbaniani, Perumal and Byramgore pars and Kardamat reef should be thoroughly inspected to determine whether green snail (*Turbo* sp.) and trocas (*Trochus* sp.) exist there in quantities worth being exploited commercially. As already mentioned sea-worn specimens of these shells are not rare at Chetlat and Kiltan, and we were repeatedly informed that larger shells were procurable at the "pars." Both shells are well known in the pearl button trade and formed the bulk of the shell being cut up in a large Japanese factory which I visited in 1907. It is worthy of note that considerable quantities of both shells are exported annually from the Mergui Archipelago off the Burma coast.

(4) The Bêche-de-mer industry already established in Kiltan appears capable of considerable extension and improvement. At present the methods of curing are the worst possible and of a nature that reduces the value of the product to a minimum. As it is now turned out, it is of the lowest grade accepted by the Chinese. Improved methods must be introduced and the curers advised how and where they may dispose of their products to the best advantage. At present poor curing and ignorance of the true value of that product result in the curers parting with their goods at such low rates as provide insufficient inducement to the islanders to prosecute the industry with vigour. It is probable that Bêche-de-mer exists in very great quantities at Cherbaniani and the other uninhabited "pars"; the extent of the available supply should be investigated concurrently with instruction in improved methods of curing and advice regarding disposal; regulations should be formulated to guard against depletion of supply. It should be noted in this latter connection that Bêche-de-mer, owing to its sluggish habits and very circumscribed habitat in the case of oceanic islands, will run great risk in the Laccadives of being fished out if the industry be found profitable and if no protective restrictions be imposed. Exactly what lines such regulations should follow cannot satisfactorily be determined without preliminary enquiries; probably a minimum size would be prescribed or a system of fishing the lagoons in rotation, giving one or two years' rest to each in turn.

(5) *Turtle breeding.*—Turtles are fairly abundant at certain seasons and might well be bred and fattened with profit in the lagoons of the inhabited islands. Turtle-breeding has been found to pay well in other countries and few places can

compete with the Laccadive lagoons in regard to the ease, security and economy with which such an industry may there be undertaken. A good market for the turtle thus reared would probably be found in Bombay. The commercial feasibility of this suggestion should be among the subjects for investigation should it be determined to study further the fishery potentialities of these interesting islands.

MADRAS,
6th February 1909.

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